TIMBER SUPPLY BRANCH

TIMBER SUPPLY REVIEW

Arrow Timber Supply Area Analysis Report

April 2000

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Analysis Report

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Preface

This report contains a timber supply analysis and a socio-economic analysis and is part of the provincial Timber Supply Review carried out by the British Columbia Forest Service. The purpose of the review is to examine the short- and long-term effects of current forest management practices on the availability of timber for harvesting in timber supply areas (TSAs) and tree farm licences (TFLs) throughout British Columbia. A review of each TSA and TFL is completed at least once every five years.

To determine allowable timber harvesting levels accurately and rationally, the Chief Forester must have an up-to-date assessment of the timber supply, based on the best available information and reflecting current management direction. **The report that follows provides only this assessment and should not be construed as a recommendation on permissible harvest levels.**

This report focuses on a single forest management scenario — current management practices. Current management practices are defined by the specifications in management plans for the timber supply area including guidelines for the protection of forest resources, the *Forest Practices Code (FPC) of B.C. Act* and official land-use decisions made by Cabinet.

Assessing the implications of only current practices rather than looking at a number of different management schemes will expedite the analysis process, allowing analysis of all TSAs in the province every five years. An important part of these analyses is an assessment of how results might be affected by uncertainties — a process called sensitivity analysis. Together, the sensitivity analyses and the assessment of the effects of current forest management on the timber supply provide a basis for discussions among stakeholders about alternative timber harvesting levels.

In addition to having an up-to-date assessment of timber supply when setting the allowable annual cut (AAC) the Chief Forester considers short- and long-term implications of alternative harvest levels, capabilities and requirements of existing and proposed processing facilities, and the social and economic objectives of the Crown. The socio-economic analysis provides the Chief Forester with some of the information necessary for these considerations.

The socio-economic analysis considers forestry activity associated with the harvesting and processing of timber harvested from the TSA within the context of timber supply and production capacity of regional industry.

This report is the third of five documents that will be released for each TSA as part of the Timber Supply Review. (The first two documents are the information report and the data package). This document provides technical information on the results of the timber supply and socio-economic analyses. A fourth document called the public discussion paper will summarize the technical information and will provide a focus for public discussions of possible timber harvest levels. The fifth will outline the Chief Forester's harvest level decision and the reasoning behind it.

Executive Summary

As part of the provincial Timber Supply Review, the British Columbia Forest Service has examined the availability of timber in the Arrow Timber Supply Area (TSA). The analysis assesses how current forest management practices affect the supply of wood available for harvesting over the short- (next 20 years), medium- (21 to 80 years from the present) and long- (beyond 80 years from the present) terms. It also examines the potential changes in timber supply stemming from uncertainties about forest growth and management practices. The purpose of the timber supply analysis is to assess the timber supply implications of current forest management, and of uncertainties about land base, growth and yield, and practices associated with current management. **The forecasts in this report should be used for discussion purposes only; they are not allowable annual cut (AAC) recommendations.**

The Arrow TSA is located in the southeastern portion of British Columbia primarily in the interior cedar-hemlock, Englemann spruce-subalpine fir and alpine tundra biogeoclimatic zones. It covers an area of approximately 741 000 hectares of which about 202 000 hectares are considered available for timber production and harvesting under current forest management practices. These practices follow the standards and legislation set out by the *Forest Practices Code* and the agreements made under the *Kootenay-Boundary Land Use Plan* (KBLUP). Within the area available for timber harvesting, most of the forests are dominated by Douglas-fir/larch species, although there are also significant areas dominated by lodgepole pine, balsam, spruce, and hemlock species.

The results of this timber supply analysis suggest that harvests can be maintained at the current AAC attributable to the Arrow TSA (609 300 cubic metres per year) for only one decade without creating future timber supply disruptions, if followed by a controlled reduction over the subsequent two decades to 493 500 cubic metres per year. The projected harvest stays at this level until decade nine when it increases to 544 000 cubic metres per year. After decade sixteen, this TSA can sustain a harvest level of 557 000 cubic metres per year for the remainder of the 250-year planning horizon.

The above results reflect current knowledge and information on forest inventory, growth, and management. However, it is important to recognize that uncertainty exists about several factors important in defining timber supply. A series of sensitivity analyses showed that these uncertainties can affect timber supply to varying degrees.

The uncertainties with the largest potential effects on projected harvests over the short term involve estimates of timber volumes in existing stands and the size of the timber harvesting land base. A TSA-wide inventory audit conducted in 1997 showed that the volume estimates for mature stands (over 60 years old) based on inventory information are not statistically different from volumes derived using ground measurements. The audit therefore suggests that the inventory accurately portrays the standing timber volume in existing stands, on average at the TSA level.

The harvest contribution from the Slocan valley, which makes up 14% of the timber harvesting land base, is subject to uncertainty. In the base case, the harvest from the Slocan valley in the short term is approximately 80 000 cubic metres per year. If the harvest from the Slocan valley is limited to 50 000 cubic metres per year, the initial harvest level from the TSA will have to decrease by about 5% in order to keep medium-term harvest levels similar to those in the base case. Further limitations on the contribution from the Slocan valley result in larger decreases to the initial harvest level obtainable from the TSA.

Factors having the largest potential effects on timber supply over the medium-term, (21 to 80 years from now), include estimates of time taken to achieve green-up conditions, incidence of root rot in regenerated stands, forest cover requirements for management of visual quality, the size of the timber harvesting land base and the estimates of timber volumes in existing stands.

The estimates of time taken to achieve green-up conditions for this TSA were derived by examining height growth data for regenerating stands in the Nelson Forest Region. Growth rates for stands in the Arrow TSA may be different from the regional averages used. Green-up heights were based on the agreements made under the *Kootenay-Boundary Land Use Plan* (KBLUP). Reduction in the time to green-up had little effect on timber supply, whereas an increase in the time substantially reduced both medium- and long-term timber supply.

Uncertainty regarding the incidence of root rot in future stands affects both volume projections and the time when stands become merchantable. While there is no conclusive data available to estimate the magnitude of the problem, the analysis shows that root rot can have a significant impact on timber supply.

Uncertainty about visual quality objectives, which apply to 36% of the timber harvesting land base, can impact both the medium- and long-term timber supply. The analysis employed the latest visual quality mapping available and current operational standards for permissible visual disturbance. If the visual absorption capacities in the visually sensitive areas were lower than modelled, then medium- and long-term timber supply would be considerably lower than shown for the base case.

Long-term timber supply is affected by uncertainties in: application of landscape-level biodiversity management guidelines, estimates of regenerated stand yields, estimates of site productivity for old-growth stands, the availability of seeds from seed orchards as well as all of the factors with large potential effects on medium-term timber supply mentioned above. Improved estimates of site productivity, seed quality and availability, and regenerated stand yields will occur as new data is collected and used to develop new models. More time is also required to assess the requirements for landscape-level biodiversity, however, this analysis uses the best data and models presently available to forecast timber supply in British Columbia.

The socio-economic analysis for the Arrow TSA indicates that the base case harvest forecast in decade one can support an estimated 693 person-years of direct employment and 908 person-years of indirect and induced employment in the province annually.

If harvested and utilized, the base case harvest level for the first decade would generate an estimated $26.7 million per year in provincial government revenues.

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Introduction

Timber supply* is the quantity of timber available for harvest over time. Assessing the timber supply involves considering physical, biological, social and economic factors for all forest resource values, not just for timber. Physical factors include the land features of the area under study as well as the physical characteristics of living organisms, especially trees. Biological factors include the growth and development of living organisms. Economic factors include the financial profitability of conducting forest operations, and the broader community and social aspects of managing the forest resource.

All of these factors are linked: the financial profitability of harvest operations depends upon the terrain, as well as the physical characteristics of the trees to be harvested. Determining the physical characteristics of trees in the future requires knowledge of their growth. Decisions about whether a stand is available for harvest often depend on how its harvest could affect other forest values, such as wildlife or recreation.

These factors are also subject to both uncertainty and different points of view. Financial profitability may change as world timber markets change. Unforeseen losses due to fire or pest infestations will alter the amount and value of timber. The appropriate balance of timber and non-timber values in a forest is an ongoing subject of debate, and is complicated by changes in social objectives over time.

Thus, before an estimate of timber supply is interpreted, the set of physical, biological and socio-economic conditions on which it is based, and which define current forest management — as well as the uncertainties affecting these conditions — must first be understood. Timber supply analysis is the process of assessing and predicting the current and future timber supply for a management unit (a geographic area). For a timber supply area (TSA)*, the timber supply analysis forms part of the information used by the Chief Forester of British Columbia in determining an allowable annual cut (AAC)* — the permissible harvest level for the area.

Timber supply projections made for TSAs look far into the future — 250 years or more. However, because of the uncertainty surrounding the information and because forest management objectives change through time, these projections should not be viewed as static prescriptions that remain in place for that length of time. They remain relevant only as long as the information upon which they are based remains relevant. Thus, it is important that re-analysis occurs regularly, using new information and knowledge to update the timber supply picture. Indeed, the *Forest Act* requires that the timber supply for management units through British Columbia be reviewed at least every 5 years. This allows close monitoring of the timber supply and of the implications for the AAC stemming from changes in management practices and objectives.

**Throughout this document, an asterisk after a word or phrase indicates that it is defined in a box at the foot of the page, as well as in the glossary.*

Timber supply
The amount of timber that is forecast to be available for harvesting over a specified time period, under a particular management regime.
Timber supply area (TSA)
An integrated resource management unit established in accordance with Section 7 of the Forest Act.

Allowable annual cut (AAC)
The rate of timber harvest permitted each year from a specified area of land, usually expressed as cubic metres of wood per year.

Introduction

Timber supply analysis involves three main steps. The first is collecting and preparing information and data in which the B.C. Forest Service forest inventory* plays a major role. The second step is using these data along with a timber supply computer model or models to make projections or estimates of possible harvest levels over time. These projections are made using different sets of assumed values or conditions for the factors discussed above. The third step is interpreting and reporting results.

The following sections outline the timber supply analysis for the Arrow TSA. Following a brief description of the area in Section 1, data preparation and formulation of assumptions are discussed in Section 2. Timber supply analysis methodology and results are presented in Sections 3 and 4. Section 5 examines the sensitivity of the results to uncertainties in the data and assumptions used. Section 6 explores the timber supply implications of alternative forest management practices. This is followed by a summary and conclusions for the timber supply analysis in Section 7. Section 8 shows results of a socio-economic analysis for the Arrow TSA. Appendixes A and B contain further details about the data and assumptions used in the analysis.

As part of the timber supply review, information is gathered on the short- and long-term implications of alternative harvest levels, and the capabilities and requirements of existing and proposed processing facilities. The socio-economic analysis provides information for the Chief Forester and the local community to better understand the potential magnitude of impacts associated with any proposed harvest level changes.

The socio-economic analysis considers the current and projected levels of forestry activity associated with the Arrow TSA within the context of regional timber supplies and production capacity. It does this by examining the profile of the region and the local forest industry; and by assessing employment and income implications of the timber harvesting levels projected in the base case.

The analysis includes estimates of the employment and income impacts associated with timber supply analysis projections by three main sectors: harvesting and other woodlands related, processing, and silviculture. Employment is measured in person-years*. Employment income is calculated using average industry income estimates.

Data on direct employment, harvest levels, and fibre flows was obtained by surveying licensees and mill operators. The information was used to estimate harvesting, processing and silviculture direct employment averages associated with the harvest and the proportion of workers living in the area. The estimates of local and provincial harvesting, processing, and silviculture direct employment were then used to determine ratios of employment per 1000 cubic metres of timber harvested.

Indirect and induced employment figures were calculated using the Arrow TSA and provincial employment multipliers* developed by the Ministry of Finance and Corporate Relations. Indirect impacts result from direct businesses purchasing goods and services; induced impacts result from direct employees purchasing goods and services. Employment coefficients* per 1000 cubic metres were also determined for the indirect and induced impacts.

Forest inventory
An assessment of British Columbia's timber resources. It includes computerized maps, a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, and a description of other forest values such as recreation and visual quality.

Person-year(s)
One person working the equivalent of one full year, defined as at least 180 days of work. If someone works full-time for 90 days, he or she accounts for 0.5 person-years.

Employment multiplier
An estimate of the total employment supported by each direct job, for example a multiplier of 2.0 means that one direct job supports one additional indirect and induced job.

Employment coefficient
The number of person-years of employment supported by every 1000 cubic metres of timber harvested; for example, a coefficient of 1.0 indicates that every 1000 cubic metres harvested supports one person-year, or 500 000 cubic metres supports 500 person-years.

Introduction

To estimate the level of employment that could be supported by alternative harvest rates, projected timber supply levels were multiplied by the calculated employment coefficients. It should be noted that employment coefficients are based on current productivity, harvest practices and management assumptions* and will not likely reflect industry conditions decades into the future. As such, the employment estimates can only be viewed as general indicators.

Management assumptions
Approximations of management objectives, priorities, constraints and other conditions needed to represent forest management actions in a forest planning model. These include, for example, the criteria for determining the timber harvesting land base, the specification of minimum harvestable ages, utilization levels, integrated resource guidelines and silviculture and pest management programs.

1 Description of the Arrow Timber Supply Area

The Arrow Timber Supply Area (TSA) is situated in southeastern British Columbia and covers approximately 741 000 hectares in the southwest portion of the Nelson Forest Region. This TSA is part of the Arrow Forest District (which also includes Tree Farm Licences (TFLs)* 23 and 3) and is administered from the forest district office in Castlegar.

The Arrow Forest District extends north from the Canada-U.S. border to the southern boundary of Glacier National Park. To the east are the Selkirk Mountains and to the west the Monashee Mountains. These two mountain ranges create a major north-south valley occupied by the Arrow Lakes-Columbia River system, a dominant feature of the area. The Slocan and Salmo River valleys are also major features.

The terrain in the Arrow Forest District is quite variable. The northern portion of the district is characterized by high ridges with deep valleys that can be narrow or wide. The southern portion has more subdued terrain, featuring lower, more rounded mountains marked by wide valleys and trenches throughout.

Forests in the Arrow TSA have the distinction of being among the most productive in the interior of the province. In addition, lower elevation forests have the greatest diversity of tree species in B.C. The dominant species in the TSA are Douglas-fir, western larch, lodgepole pine, spruce, subalpine fir, and western hemlock

The current allowable annual cut (AAC) for the Arrow TSA is 619 000 cubic metres. This level was set in 1995 and was unchanged from the previous AAC determination. Since 1995, woodlot licences with a total AAC of 9700 cubic metres have been issued. Woodlot licences are administered separately from the TSA, thus the AAC currently attributable to the TSA and that is used for this report is 609 300 cubic metres. In this timber supply analysis, about 54% of the TSA (403 000 hectares) is considered Crown forest land managed by the B.C. Forest Service. Approximately 50% of that Crown forest (about 202 000 hectares, or 27% of the total TSA land base) is considered available for harvesting under current management practices.

Significant changes that influence forest management in the Arrow TSA have occurred since the last timber supply review was completed. These changes include:

- implementation of the *Forest Practices Code**;
- formal establishment of landscape units* and biodiversity* emphasis options;
- designation of scenic corridors; and,
- management direction from the *Kootenay-Boundary Land Use Plan — Implementation Strategy.*

The largest communities in the Arrow TSA are Trail, Castlegar and Rossland, in that order. Together these communities are home to about 40% of the TSA's population of 45,755 people (1996 census). Eight smaller communities and several unincorporated areas are also located in this TSA.

Recreational use of the forests in the Arrow TSA is high due to the proximity of provincial and national parks and the exceptional natural scenery. The 1995 *Kootenay-Boundary Land Use Plan* resulted in the creation of 16 parks, including four new protected areas* within the Arrow TSA (Syringa Creek, Goat Range, Gladstone and Granby). The lakes, rivers and mountainous terrain of the area provide a wide range of front — and back — country recreational opportunities including mountain-biking, hiking, fishing, camping, wildlife viewing, boating, heli-skiing, snow-mobiling and cross-country and downhill skiing.

Tree farm licence (TFL)
Provides rights to harvest timber, and outlines responsibilities for forest management, in a particular area.
Forest Practices Code
Legislation, standards and guidebooks that govern forest practices and planning, with a focus on ensuring management for all forest values.
Landscape unit
A planning area based on topographic or geographic features, that is appropriately sized (up to 100 000 hectares), and designed for application of landscape-level biodiversity objectives.

Biodiversity (biological diversity)
The diversity of plants, animals and other living organisms in all their forms and levels of organization, and includes the diversity of genes, species and ecosystems, as well as the evolutionary and functional processes that link them.
Protected area
A designation for areas of land and water set aside to protect natural heritage, cultural heritage or recreational values (may include national park, provincial park, or ecological reserve designations).

The Arrow TSA also contains abundant water resources. Approximately 47% of the area considered available for harvesting is located within watersheds* that are licensed for domestic use.

1.1 The environment

The Arrow TSA is located in the interior wet-belt of the province, making it a very productive region for tree growth. Within the TSA, two main ecosections and four biogeoclimatic zones* are recognized. These ecosystem units reflect differences in terrain, climate and the species of trees that are present.

The Central Columbia Mountains (CCM) ecosection covers the upper Arrow Lake valley and the Slocan valley. It is characterized by high ridges with deep wide-trenched and narrow valleys. The main valleys have north-south orientations, with tributary drainages* flowing east or west. In this ecosection, three biogeoclimatic zones are present.

In the valley bottoms and on lower slopes, is the Interior-Cedar Hemlock (ICH) zone. The major species include western redcedar, western hemlock, Douglas-fir, western larch, and hybrid white spruce. Less common species include lodgepole pine, western white pine, subalpine fir and deciduous species such as trembling aspen, black cottonwood and paper birch.

At mid to higher elevations, in the Engelmann Spruce-Subalpine Fir (ESSF) zone, forests are dominated by Engelmann spruce, subalpine fir and lodgepole pine. Other less common species include whitebark pine, western white pine, western hemlock, western redcedar, Douglas-fir and western larch. The Alpine Tundra (AT) zone occurs at the highest elevations and consists primarily of rock, snow and ice, with only a minor component vegetated with grasses, sedges, saxifrages, willows, buttercups and mountain heather.

The Selkirk Foothills ecosection covers the lower Arrow Lake-Columbia River valley. This ecosection has more subdued terrain than the Central Columbia Mountains, and features a lower mountain relief marked by wide valleys and trenches throughout. The main valley orientation is again north-south, with tributary streams flowing either east or west.

In this ecosection, the Interior-Cedar Hemlock zone also occupies lower elevations, and includes ponderosa pine and grand fir, as well as the species occurring in the Central Columbia Mountains ecosection. The Engelmann Spruce-Subalpine Fir zone occurs at mid to higher elevations and the Alpine Tundra zone occurs on only a few high ridges. A small pocket of the Interior Douglas-fir (IDF) zone is also found at low elevations in the driest part of this ecosection (south-facing slopes). Other pockets of unique and limited habitat exist within the Interior-Cedar Hemlock zone and have been earmarked for special attention by the Ministry of Environment, Lands and Parks (MELP).

The Arrow TSA supports an abundance and wide variety of wildlife species, including more than 60 species of birds (both resident and migratory) and all ungulate species present in B.C. (including Rocky Mountain bighorn sheep, white-tailed and mule deer, moose, mountain goats, elk and caribou). Other large mammals include cougar, grizzly bear, wolf and black bear. Smaller mammals include bobcat, lynx, coyote, fisher, marten, chipmunk, marmot and wolverine. Two uncommon reptiles are also found in this TSA: the western skink and the northern alligator lizard.

A wide variety of fish species are found within the Arrow Forest District. The most notable is the trophy-sized Gerrard rainbow trout, which is unique to this region and of provincial significance. A unique variety, the yellow-fin Gerrard rainbow trout, is indigenous only to the Arrow Lakes.

Watershed
An area drained by a stream or river. A large watershed may contain several smaller watersheds.
Biogeoclimatic zones
A large geographic area with broadly homogeneous climate and similar dominant tree species.

Drainage
The surface and sub-surface water derived within a clearly defined catchment area, usually bounded by ridges or other similar topographic features, encompassing part, most, or all of a watershed. The term is sometimes used to describe an operating area or location.

Another important species is the Whistle Sturgeon which is now considered to be a threatened species. Other sport fish include Dolly Varden, kokanee, whitefish, bull trout, brook trout, burbot and walleye; many species of coarse fish occur as well. Protection of fisheries values throughout the Arrow Forest District is especially important because of the impact the Columbia River dams have had.

The majority of species that are considered at risk or regionally significant and that occur or potentially may be found in the Arrow TSA are presented in Table 1.

Table 1. Vulnerable, endangered and threatened species

Endangered or threatened (red-listed)	Vulnerable (blue-listed)	
prairie falcon	white-throated swift	Bull trout
white sturgeon	great blue heron	Townsend's big-eared bat
umatilla dace	short-eared owl	*luscus* wolverine
badger	American bittern	fisher
	canyon wren	woodland caribou (southern pop.)
	bobolink	grizzly bear
	Lewis' woodpecker	rubber boa
	Williamson's sap–sucker (*thyroideus*)	painted turtle
	mottled sculpin	western rattlesnake
	shorthead sculpin	

Source: B.C. Conservation Data Centre, November 1, 1998.

In terms of the requirements for biodiversity, the forests within the Arrow TSA is predominantly immature. Old-growth forests are relatively few, dispersed and more common at higher elevations. In addition, riparian habitats* and deer and caribou winter range are of particular importance in this TSA.

Current forest management practices follow the legislation and guidelines set out by the *Forest Practices Code*. Consequently, the protection of wildlife and the environment are managed through the Code. In addition, the provincial government has adopted as policy the *Kootenay-Boundary Land Use Plan – Implementation Strategy*. This has provided direction regarding landscape units, biodiversity-emphasis objectives, caribou habitat, ungulate winter range, scenic corridors, community and domestic watersheds, and other forest cover constraints.

1.2 First Nations

Currently there are no First Nations communities in the Arrow TSA. However, the Ktunaxa, Shuswap, and Okanagan Nations have identified traditional territories within the Arrow TSA.

The Ktunaxa/Kinbasket Tribal Council, on behalf of the Ktunaxa Nation, has submitted to the provincial government a comprehensive land claim covering the southeast corner of the province, including part of this TSA. The Westbank First Nation, a member of the Okanagan Nation, has also entered into land claim negotiations for a portion of the Arrow TSA. The Shuswap Nation Tribal Council, though not participating in the formal treaty process, have stated their interest in taking part in some form of negotiation with the provincial government regarding their traditional territory.

An Archaeological Overview Assessment (AOA) for the entire Arrow Forest District was completed in March 1996. This AOA is the basis for determining areas and sites that may require further assessment in the form of an Archaeological Impact Assessment (AIA). AIAs are carried out as part of operational planning. The findings of AIAs that have been completed were considered in this timber supply review.

Riparian habitat
The stream bank and flood plain area adjacent to streams or water bodies.

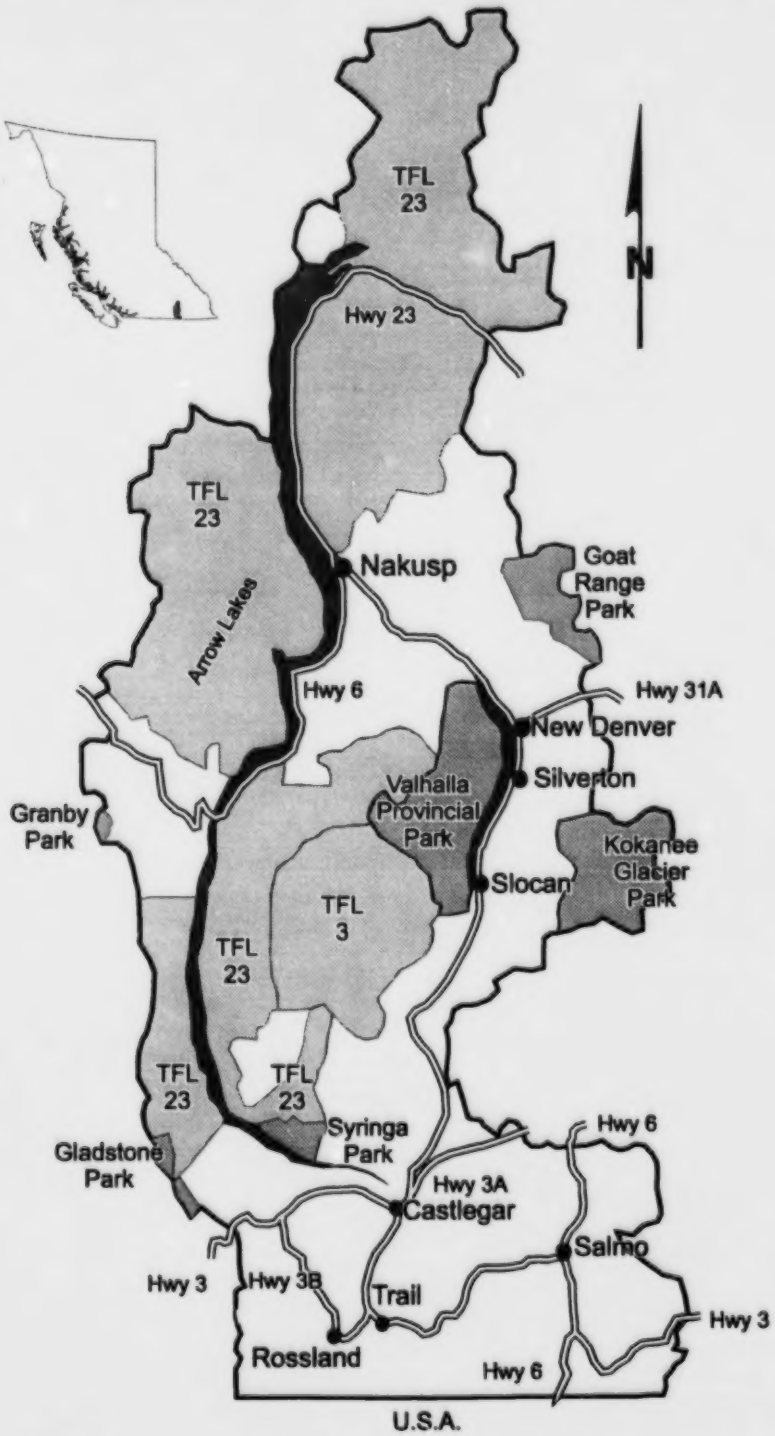


Figure 1. Map of the Arrow Timber Supply Area, Nelson Forest Region.

2 Information Preparation for the Timber Supply Analysis

Information required for timber supply analysis can be divided into three general categories: land base inventory; timber growth and yield; and management practices.

2.1 Land base inventory

The various sources of land base information used in this analysis were compiled into one computer file in 1999 by the Ministry of Forests, Arrow Forest District. This file contains information on the forest land in the Arrow TSA including general geographic location, area, nature of forest cover (such as number and type of trees, age, and timber volume), and other characteristics such as environmental sensitivity and physical accessibility (operability*). Stand attributes such as tree height, stocking* and age have been projected to 1998. The inventory file has been updated to account for timber harvesting up to 1998 for the Arrow TSA.

The inventory file represents the land base for the entire TSA. It includes information on land that does not contain forest, and other areas where timber harvesting is not expected to occur. Examples are land set aside for parks, areas needed to protect wildlife habitat, areas in utility and transportation corridors, and residential and industrial development. A description of these areas specific to the Arrow TSA is provided below. These types of areas do not contribute to the timber harvesting land base* of the Arrow TSA. Before assessing timber supply, these non-contributing areas are identified and separated from the timber harvesting land base.

Identifying areas as not contributing to timber supply does not mean the area is removed from the Arrow TSA. The B.C. Forest Service still manages the entire area of the TSA (except for designated areas under the jurisdiction of other agencies) as a land unit that contributes a mix of timber and non-timber values. The timber supply is managed within this integrated resource context, and the analysis described herein is consistent with this philosophy.

This section describes the types of areas that do not contribute to the timber harvesting land base. Use of the term timber harvesting land base in this report does not mean the area is open to unrestricted logging. Rather, it implies that forests in the area contain timber of sufficient economic value, and sites of adequate environmental resilience, to accommodate timber harvesting with due care for other resources.

For the Arrow TSA, the following types of areas were excluded from the timber harvesting land base.

- not managed by the B.C. Forest Service — these are non-Crown areas (such as private land) and other areas that are not administered as part of the TSA (e.g., woodlots). The forested portions of parks and ecological reserves contribute towards biodiversity values.
- non-forest areas — areas not occupied by productive forest cover (e.g., rock, swamp, alpine areas and water bodies).
- non-commercial cover areas — areas occupied by non-commercial tree or brush species.

Operability
Classification of an area considered available for timber harvesting. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.
Stocking
The proportion of an area occupied by trees, measured by the degree to which the crowns of adjacent trees touch, and the number of trees per hectare.

Timber harvesting land base
Crown forest land within the timber supply area that is currently considered feasible and economical for timber harvesting.

- inoperable areas* — areas classified as unavailable for harvest for terrain-related or economic reasons. Characteristics used to define operability include slope, topography (e.g., presence of gullies or exposed rock), difficulty of road access, soil stability and elevation.
- environmentally sensitive areas* — portions of the areas considered environmentally sensitive and/or significantly valuable for other resources.
- sites with low timber productivity — areas occupied by forest with low timber-growing potential.
- deciduous-leading stands — deciduous species are generally not used in this TSA.
- problem forest types — stands which are physically operable and exceed low site criteria yet are not currently utilized or have marginal merchantability.
- riparian area* — area otherwise available for timber production, a portion of which is assumed to be unavailable for harvesting to provide protection for riparian and stream ecosystems.
- existing unclassified roads, trails and landings — areas of forest land that have been removed from timber production due to access development and harvesting to date.
- goshawk nests — whenever goshawk or great blue heron nests are encountered in the Arrow TSA, a reserve zone is established to preserve the nesting habitat.
- Dewdney trail — this heritage trail has a 100-metre reserve on each side where no timber harvesting is permitted.
- wildlife tree* patch areas — areas reserved within and along the edges of cutblocks* for the maintenance of stand-level biodiversity* (stand structure), primarily for conservation or enhancement of wildlife.
- Timber Licences —Timber Licences provide the holder rights to harvest mature timber from the licence area. These areas revert to the TSA when they have been harvested and satisfactorily restocked, (i.e., free-to-grow) by the licensee.

Inoperable areas
Areas defined as unavailable for harvest for terrain-related or economic reasons. Characteristics used in defining inoperability include slope, topography (e.g., the presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality. Operability can change over time as a function of changing harvesting ***technology and economics.***
Environmentally sensitive areas
Areas with significant non-timber values, fragile or unstable soils, or impediments to establishing a new tree crop, or areas where timber harvesting may cause avalanches.
Riparian area
Areas of land adjacent to wetlands or bodies of water such as swamps, streams, rivers or lakes.

Wildlife tree
A standing live or dead tree with special characteristics that provide valuable habitat for conservation or enhancement of wildlife.
Cutblock
A specific area, with defined boundaries, authorized for harvest.
Stand-level biodiversity
A stand is a relatively localized and homogeneous land unit that can be managed using a single set of treatments. In stands, objectives for biodiversity are met by maintaining specified stand structure (wildlife trees or patches), vegetation species composition and coarse woody debris levels.

A more detailed description of these categories, including specific criteria for removal is located in Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis." Table 2 summarizes the areas in each category, and shows the area of the timber harvesting land base. The column "Crown forest area by classification" provides the total forest area managed by the B.C. Forest Service within the given category. For example, while there is a total of 81 538 hectares of forested land classified as environmentally sensitive area (ESA) outside of community watersheds, only 31 932 hectares were removed specifically due to environmental sensitivity. The difference arises because one area can be in more than one classification (e.g., inoperable and ESA), and the actual area deducted depends on the point at which the reduction occurs in the sequence. Further, partial reductions are sometimes employed to represent situations where parts of areas are retained to protect a particular value.

2 Information Preparation for the Timber Supply Analysis

Table 2. Determination of the timber harvesting land base for the Arrow TSA

Classification	Crown forest area by classification	Area (hectares)	Per cent of total TSA area	Per cent of Crown forest land
Total TSA area		740 777	100.0	
Not managed by the B.C. Forest Service		131 855	17.8	
Non-forest		205 932	27.8	
Total forest area managed by the Forest Service (Crown forest)		**402 990**	**54.4**	**100.0**
Reductions to Crown forest:				
Non-commercial forest	5 901	5 901	0.8	1.5
Inoperable areas	120 390	115 943	15.7	28.8
Environmentally sensitive areas (ESAs) outside of community watersheds	81 538	31 932	4.3	7.9
ESAs within community watersheds	20 819	11 567	1.6	2.9
Sites with low productivity	12 481	3 448	0.5	0.9
Deciduous-leading stands	16 708	8 340	1.1	2.1
Problem forest types	2 104	1 102	0.1	0.3
Riparian areas	17 458	8 975	1.2	2.2
Current roads, trails and landings	7 252	5 241	0.7	1.3
Goshawk nests	58	42	0.0	0.0
Dewdney trail	239	117	0.0	0.0
Wildlife tree patch (WTP) area	14 105	7 363	1.0	1.8
Timber licences	2 108	818	0.1	0.2
Total current reductions		200 789	27.1	49.8
Current timber harvesting land base (includes 730 hectares of timber licences and 5844 hectares not satisfactorily restocked (NSR)* land)		**202 201**	**27.3**	**50.2**
Future land base changes				
Future road reductions		-11 702		
Timber licence reversions		+818		
Long-term timber harvesting land base		**191 317**	**25.8**	**47.5**

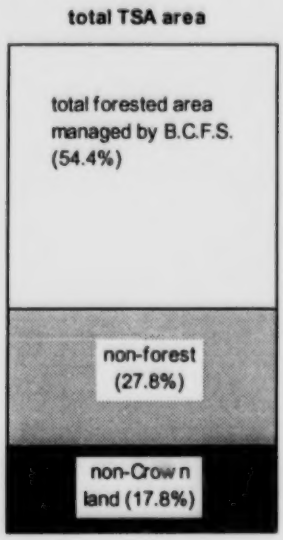
Not satisfactorily restocked (NSR) areas
An area not covered by a sufficient number of well spaced tree stems of desirable species. Stocking standards are set by the B.C. Forest Service. Areas harvested prior to 1987 and not yet sufficiently stocked according to standards are classified as backlog NSR. Areas harvested or otherwise disturbed since 1987 are classified as current NSR.

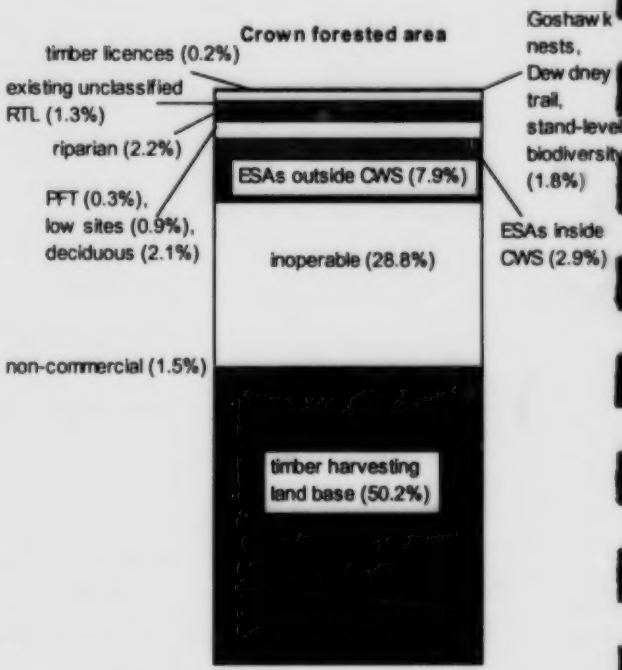
2 Information Preparation for the Timber Supply Analysis

The current timber harvesting land base in the Arrow TSA represents about 27% of the total TSA area and about 50% of the forest area managed by the B.C. Forest Service (Crown forest).

Figure 2 represents both the total Arrow TSA area, and the Crown forested land base. The total area chart shows that about 46% of the total land base is classified as not managed by B.C. Forest Service, or non-forest. The Crown forested chart details the categories of forest land and shows that about 50% of the Crown forest land in the Arrow TSA is considered to be unavailable for harvesting. The main reasons for unavailability are physical or economic inoperability and environmental sensitivity. Approximately 50% of the Crown forest is considered available for timber harvesting (including NSR and timber licences which have already been harvested and reverted to Crown ownership).

The current timber harvesting land base is approximately 13 700 hectares (6.4%) smaller than in the last timber supply review. This is mostly due to the creation of parks, and management for riparian areas and stand-level biodiversity under the *Forest Practices Code*.





TSA=timber supply area
B.C.F.S.=British Columbia Forest Service
RTL=roads, trails and landings
PFT=problem forest types
ESAs=environmentally sensitive areas
CWS=community watersheds

Figure 2. Composition of the total and Crown forested land bases — Arrow TSA, 2000.

Figure 3 shows overall distribution of biogeoclimatic (BEC) variants in the Crown forested area and the forested portions of provincial parks in the TSA. The last number for the variant names shown in Figure 3 represents the natural disturbance type (NDT)*. This distinction is necessary because for some variants (e.g. ESSFwc_1) the name alone is not sufficient to uniquely identify the variant. Also shown is the proportion of each BEC variant that is in the timber harvesting land base. For example, the ICHmw2 variant makes up 42.8% of the Crown forested area and the forested portions of provincial parks, while 60.3% of the total area of ICHmw2 is within the timber harvesting land base.

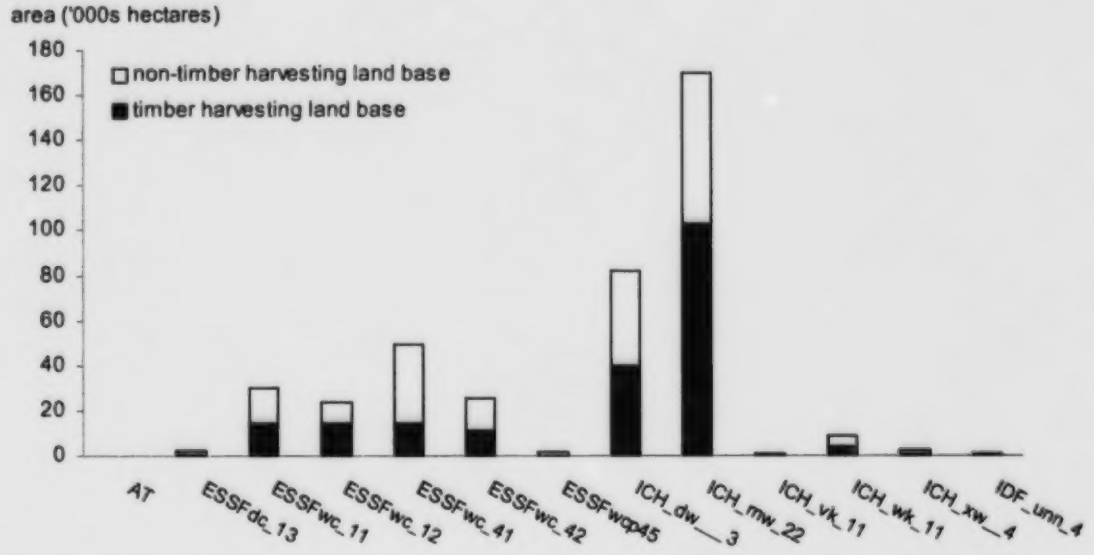


Figure 3. Forested area by biogeoclimatic classification — Arrow TSA, 2000.

Natural disturbance type (NDT)
An area that is characterized by a natural disturbance regime, such as wildfires, which affects the natural distribution of seral stages. For example areas with less stand-initiating disturbance have more older forests, and generally a greater abundance of species.

Figure 4 shows the current composition of the timber harvesting land base by dominant tree species. Douglas-fir/larch species dominate stands on about 41% of the timber harvesting land base, with pine dominating on 18%, cedar/hemlock 14%, balsam 14% and spruce 13%. After harvest, most stands are expected to be regenerated to the same species, except the cedar/hemlock and balsam sites, which will mostly be regenerated to fir, pine and spruce.

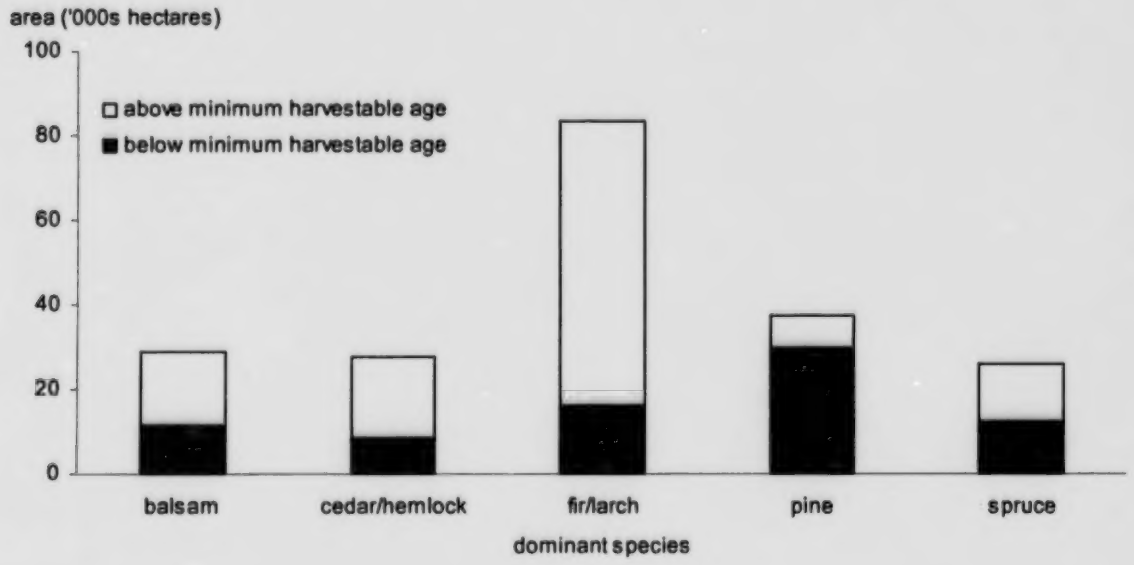


Figure 4. Area by dominant species — Arrow TSA timber harvesting land base, 2000.

Figure 4 also shows the proportion of area of each species that is either younger or older than the minimum harvestable age (see Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis" for details on the minimum harvestable age for each species). In total, about 62% of stands in the timber harvesting land base are at or above the minimum harvestable age. There is variation around this proportion for each of the species groupings: 81% of fir/larch stands, 61% of balsam stands, 70% of cedar/hemlock stands, 20% of the pine stands and 52% of spruce stands are currently older than the minimum harvestable age.

Given the different proportions of area below minimum harvestable age for each species group, it would appear that harvesting and salvage operations in the Arrow TSA have concentrated mostly on pine, followed by fir and spruce. As noted previously, cedar/hemlock and balsam stands have been converted to fir, pine and spruce stands, which adds immature area to these categories, and expands the indicated harvesting in these stand types.

Figure 5 shows the distribution of site productivity of the dominant stand types within the timber harvesting land base. Sixteen per cent of the stands are classified as having relatively good site productivity. Stands with medium site productivity occupy 58% of the area, and those with a relatively poor site productivity, 26%. Sites of very low productivity (not capable of producing 150 cubic metres per hectare by age 140 years) are excluded from the timber harvesting land base. Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis" contains a definition of good, medium and poor site productivity for each of the species groups shown in Figure 5.

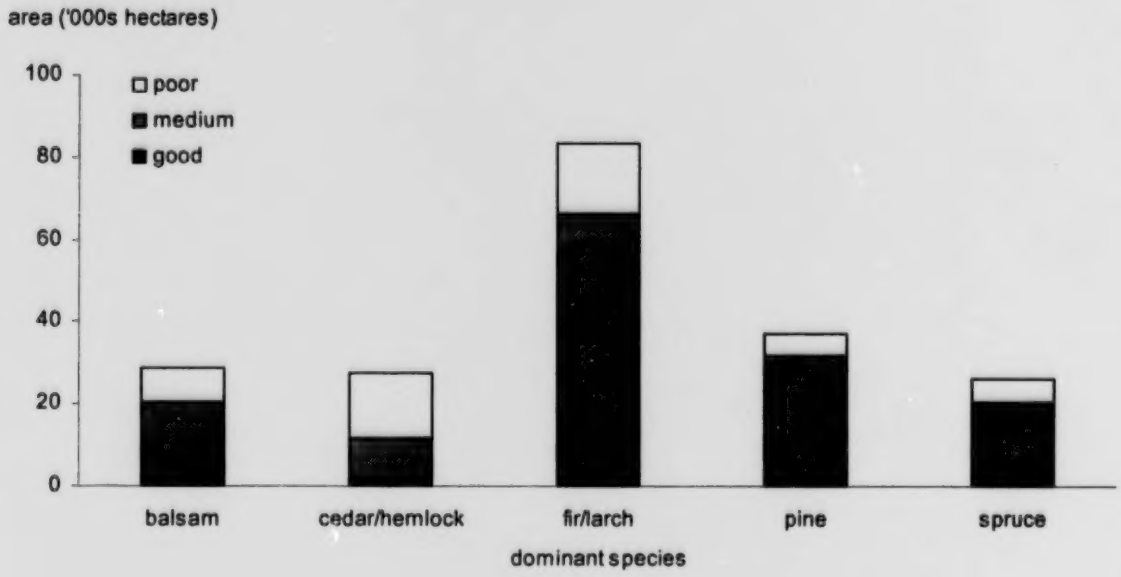


Figure 5. Area by predominant species and site productivity — Arrow TSA timber harvesting land base, 2000.

Figure 6 shows the current age composition of all Crown forested area and the forested portions of provincial parks in the Arrow TSA. Currently, very few stands are older than 250 years both within the timber harvesting land base and outside of the timber harvesting land base. About 10% of stands in the total forested area are 20 years or younger, 52% are between 21 and 100 years old, 34% are between 101 and 250 years of age, and 4% are older than 250 years. In the timber harvesting land base almost 62% of the stands are at or above the minimum harvestable age applicable to the stand. In this portion of the land base 15% of the stands are 20 years or younger, 48% are between 21 and 100 years old, 34% are between 101 and 250 years of age, and 3% are older than 250 years.

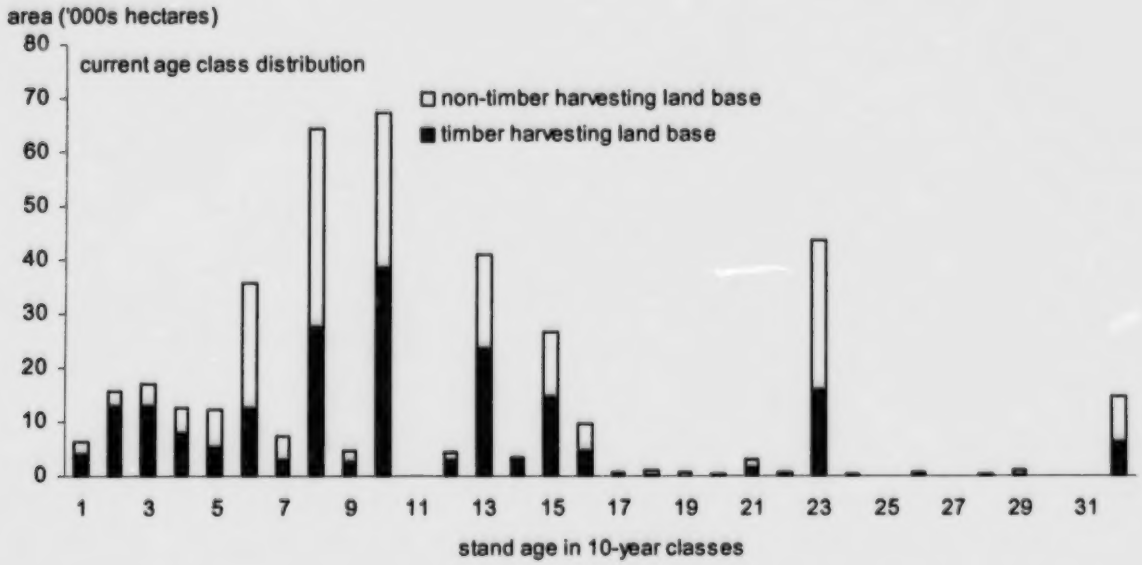


Figure 6. Current age class composition — Arrow TSA forested land base, 2000.

The age class distribution of forested stands excluded from the timber harvesting land base also affects timber supply. In the case of the Arrow TSA, 49% of the total forest land base is covered by these stands which, although they do not contribute directly to the timber supply, can affect how much harvesting can be conducted and the pattern of the harvesting within the TSA by providing old-forest and biodiversity attributes. Only 5% of these "non-timber harvesting land base" stands are older than 250 years. Five per cent of the stands are 20 years or younger, 55% are between 21 and 100 years old, and 35% are between 101 and 250 years of age.

2.2 Timber growth and yield

Timber growth and yield refers to the prediction of the growth and development of forest stands over time. Forest stands have many characteristics that change over time that could be the subject of growth and yield (for example, number of trees per area, tree diameter, tree height, species composition). Since timber supply analysis concentrates on timber volumes available over time, the most relevant measure for this analysis is volume per area (in British Columbia, cubic metres per hectare). An estimate of timber volume in a stand assumes a specific utilization level, or set of dimensions, that establish the minimum tree and log sizes that are removed from a site. Utilization levels used in estimating timber volumes specify minimum diameters both near the base and the top of a tree.

Two growth and yield models were used to estimate timber volumes for the Arrow TSA analysis. The variable density yield prediction (VDYP) model developed by the B.C. Forest Service, Resources Inventory Branch, was used for estimating volumes in unmanaged coniferous stands. The table interpolation program for stand yields (TIPSY), developed by the B.C. Forest Service, Research Branch was used to estimate yields for coniferous managed stands. Managed stands were defined as Douglas-fir, larch and spruce stands less than 21 years of age; cedar, hemlock, balsam and pine stands less than 11 years of age; and those stands that will be established in the future.

Volume estimation and prediction is subject to uncertainty due to the procedures used for estimating site productivity, limited experience with second-growth in British Columbia, and the long time frame over which trees grow. Sensitivity analyses described in Section 5, "Timber Supply Sensitivity Analyses," address the possibility that actual timber volumes may be different from estimates used in this analysis.

Based on timber volume estimates*, the current timber inventory on the timber harvesting land base is approximately 39.2 million cubic metres. About 33.7 million cubic metres, or 86%, of the total, are currently merchantable; that is, older than minimum harvestable age. The merchantable volume of forests currently greater than 140 years old is approximately 11 million cubic metres.

2.3 Management practices

Timber supply depends directly on how the forest is managed for both timber and non-timber values. Therefore, levels of management activity must be defined for the timber supply analysis process. The *Forest Practices Code of British Columbia Act* and associated regulations, and agreements made under the *KBLUP Implementation Strategy* guide forest management practices in the Arrow TSA. The focus of the Timber Supply Review is to assess timber supply based on current management practices as implemented in plans for the area. Staff in the Arrow Forest District provided descriptions for the following management practices:

- Silviculture practices — reforestation activities required to establish free-growing* stands of acceptable tree species. Most areas in the Arrow TSA are harvested using a clearcut harvesting* system and restocked by planting.

Volume estimates (yield projections)
Estimates of yields from forest stands over time. Yield projections can be developed for stand volume, stand diameter or specific products, and for empirical (average stocking), normal (optimal stocking) or managed stands.

Free-growing
An established seedling of an acceptable commercial species that is free from growth-inhibiting brush, weed and excessive tree competition.

Clearcut harvesting
A harvesting method whereby all trees that meet utilization standards are harvested. The harvested site is then regenerated to acceptable standards by appropriate means including planting and natural seeding.

- Incremental silviculture — where necessary, stands are spaced early in their development to ensure young trees are well distributed to maximize growth. Improved seed from seed orchards is used when possible to increase productivity. There is currently limited availability of seedlings originating from seed orchards in the Arrow TSA, however, there are plans to increase the production for future planting.
- Forest health and unsalvaged losses* — timber losses to fire and pest (insect) damage are expected to average 28 720 cubic metres per year over the next 100 years, decreasing to 23 000 cubic metres per year after this time as the white pine blister rust problem is reduced.
- Utilization levels — minimum sizes of trees, and logs to be removed during harvesting.
- Patch-size distribution and green-up* — in the Arrow TSA, approval of harvesting activities is contingent on previously harvested stands reaching a desired condition, or green-up (two metres in height for integrated resource management* areas), before adjacent stands may be harvested. The purpose of patch-size distribution guidelines is to have a variety of different-sized openings spread across the landscape. This analysis does not model patch-size distribution, but the objective to prevent timber harvesting from becoming overly concentrated in any landscape unit is incorporated by limiting the area that does not meet green-up conditions to a maximum of 25% in the integrated resource management (IRM) area.
- Caribou habitat was protected by ensuring that at least 40% of the area identified as caribou habitat was covered by forest greater than 140 years old and at least 10% of the forest was greater than 250 years old. There were also provisions that no more than 25% of the forest could be less than two metres tall.
- Ungulate winter range — in addition to the caribou habitat, areas identified as ungulate winter range (UWR) were required to have at least 40% of the forest greater than 100 years as well as meet the green-up requirements of no more than 25% less than two metres tall.
- Protection of environmentally sensitive areas — areas where potentially unstable soils, avalanche tracks, recreation activities, forest regeneration problems and habitat for various wildlife have been identified. To maintain ecological or other resource values, land has been partially or wholly removed from the timber harvesting land base. Of the total of 102 357 hectares identified as ESA, only 9.6% remain in the timber harvesting land base after all the other area reductions.
- Domestic and community watersheds — within class 1 domestic watersheds a maximum of 15% of the area may be less than the green-up height of six metres. Class 2 domestic watersheds and community watersheds are allowed to have a maximum of 20% of the area below the green-up height, whereas class 3 domestic watersheds are allowed 25%. Domestic and community watersheds cover 47% of the timber harvesting land base and may overlap with areas managed for other values such as wildlife habitat or scenic values.

Unsalvaged losses
The volume of timber killed or damaged annually by natural causes (e.g., fire, wind, insects and disease) and not harvested.

Green-up
The time needed after harvesting for a stand of trees to reach a desired condition (usually a specific height) — to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics — before harvesting is permitted in adjacent areas.
Integrated resource management
The identification and consideration of all resource values, including social, economic and environmental needs, in resource planning and decision-making.

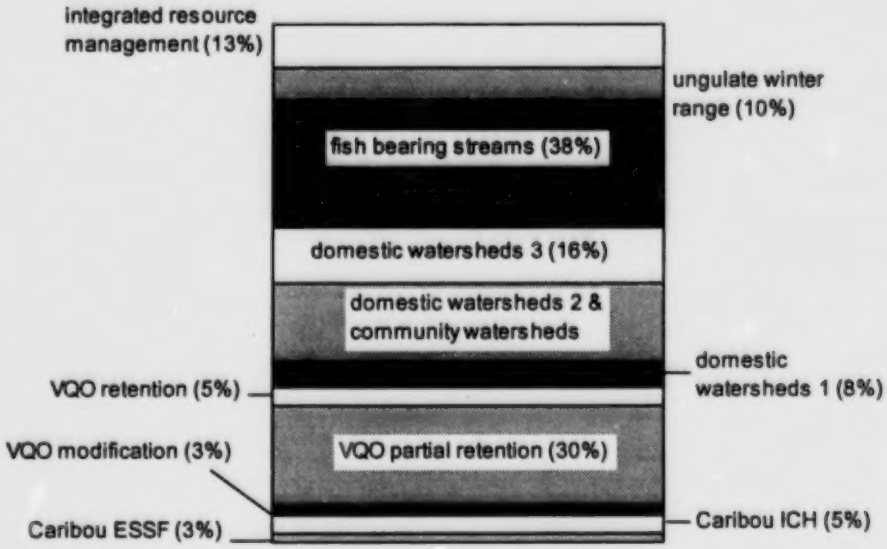
- Protection of regionally significant fish-bearing streams — the watersheds where these streams originate require management practices similar to those in domestic watersheds in order to protect fish habitat. In these watersheds a maximum of 25% of the area is allowed to have forest cover less than six metres tall.
- Maintenance of scenic values — maintaining important scenic values requires that visible evidence of harvesting must be kept within limits in some areas of the Arrow TSA. The maximum proportion of each scenic area* that may be covered by young stands that do not meet green-up requirements varies depending on the forest characteristics and the visual quality class (VQC) for each area. In areas classified as VQC retention, 5% may be less than seven metres tall. Fifteen per cent may be less than seven metres tall in partial retention classes, whereas 25% may be less than six metres tall in the modification VQC.
- Minimum harvestable ages (MHA) — the time it takes for stands to grow to a merchantable condition. The criteria used to define minimum harvestable ages were that stands should have, on average, a volume of at least 150 cubic metres per hectare and the trees should have a minimum diameter at breast height of 25 centimetres. For unmanaged stands the diameter criterion was an average of all stems whereas for managed stands the diameter criterion was an average of the largest 250 stems per hectare. Actual harvest age may be greater but not less than the minimum, and will depend on ages of other available stands, forest cover objectives* and overall timber harvest targets.
- Landscape-level biodiversity*— to maintain biological diversity throughout a landscape unit, the *Forest Practices Code* contains targets for the proportion of the area in each biogeoclimatic variant* that should be covered by stands with old- and mature-forest characteristics. The Arrow Forest District has legally completed the process of establishing landscape units and biodiversity–emphasis options for biogeoclimatic variants within the Arrow TSA (see Section A.4.9, "Forest cover requirements" in Appendix A for details regarding landscape-level biodiversity).

The data package for the Arrow Timber Supply Area (TSA) was released in January 1999. As a result of public input, changes were required to the data package (e.g., decreased green-up heights for domestic and community watersheds). The revised data package, which includes detailed descriptions of the management practices and the assumptions used to incorporate them into the analysis, is presented in Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis" of this document.

Scenic area
Any visually sensitive area or scenic landscape identified through a visual landscape inventory or planning process carried out or approved by a district manager.
Forest cover objectives
Specify desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives. General adjacency and green-up guidelines are also specified using forest cover objectives.

Landscape-level biodiversity
The Forest Practices Code Biodiversity Guidebook *provides objectives for maintaining biodiversity at both the landscape level and the stand level. At the landscape level, guidelines are provided for the maintenance of seral stage distribution, patch size distribution and landscape connectivity.*
Biogeoclimatic (BEC) variant
A subdivision of a biogeoclimatic zone. Variants reflect further differences in regional climate and are generally recognized for areas slightly drier, wetter, snowier, warmer or colder than other areas in the subzone.

Figure 7 shows the proportions of the timber harvesting land base according to the forest management objectives for those areas. The total area shown in the bar chart exceeds the timber harvesting land base by 53%. This is because more than one management objective may be applied to the same area; for example, all or part of a domestic watershed may also be managed for visual quality. An area managed for an objective such as VQO partial retention includes non-timber harvesting land base as well as timber harvesting land base. The percentages shown in Figure 7 are only for the timber harvesting land base portion of that management objective.



Note: Management groups total more than the timber harvesting land base because of overlaps.

Figure 7. Timber harvesting land base by management emphasis — Arrow TSA timber harvesting land base, 2000.

3 Timber Supply Analysis Methods

The Forest Service Simulator (FSSIM) model version 3.0 was used for this analysis. The simulation model uses information about the timber harvesting land base, timber volumes, and the management regime to represent how trees grow and are harvested over a long period of time. Generally, only the results for the first 250 years are shown graphically in this report because the harvest level remains constant after that time.

Similar to other models, the FSSIM model assumes that trees grow according to provided yield projections and are harvested according to either a volume target or a specified objective set by the analyst, such as harvest volume maximization. FSSIM also allows the use of forest cover guidelines that specify the desired age composition of the forest. These guidelines can be used to examine the effects of green-up prescriptions and requirements for older forest. For example, guidelines might specify that no more than some maximum percentage of the forest can be younger than a specified green-up age, or that some minimum percentage of the forest must be in older age classes to provide wildlife habitat.

This type of analysis is used to determine the timber supply implications of a particular forest management regime. The results of the analysis are especially important in determining allowable cuts that will not restrict options of future resource managers, and that will assist local B.C. Forest Service staff to administer their programs according to relevant guidelines and principles. However, the results of the analysis are not meant to be taken as recommendations of any particular AAC.

The main results of the analysis are forecasts of potential timber harvests and timber inventory changes (ages and volumes) over time. Although this information gives field staff only very limited guidance in the design of operational activities such as harvesting block location and silviculture planning, it does help ensure that the timber harvest level supports rather than hinders sustainable forest management in the field.

4 Results

This section presents results of the timber supply analysis for the Arrow TSA. The base case harvest forecast* uses the most recent assessments of current forest management, the land available for timber harvesting, and timber yields as described in Section 2, "Information Preparation for the Timber Supply Analysis." Because forest management is inherently a long-term venture, uncertainty surrounds much of the information important in determining timber supply. This uncertainty will be discussed in Section 5, "Timber Supply Sensitivity Analyses." The base case provides only a pa.. of the timber supply picture for the Arrow TSA, and should not be viewed in isolation of the sensitivity analysis*.

4.1 Base case and alternative flow harvest forecasts

As explained earlier, the current AAC for the Arrow TSA is 619 000 cubic metres per year, but because of the removal of woodlot licence area from the TSA, this report considers the current AAC attributable to the TSA to be 609 300 cubic metres per year. Figure 8 shows the base case harvest forecast for the Arrow TSA. This analysis suggests that a harvest level of 609 300 cubic metres per year can be maintained for one decade followed by a reduction in the harvest level over the subsequent two decades to 493 500 cubic metres per year. In decade nine the harvest level increases to 544 000 cubic metres per year. The long-term harvest level* of 557 000 cubic metres per year is reached in decade sixteen.

Unsalvaged losses due to natural forces such as insects and fire are estimated to be 28 720 cubic metres per year for the first nine decades and 23 000 cubic metres per year for the remainder of the planning horizon and have been subtracted from all harvest forecasts shown in this report.

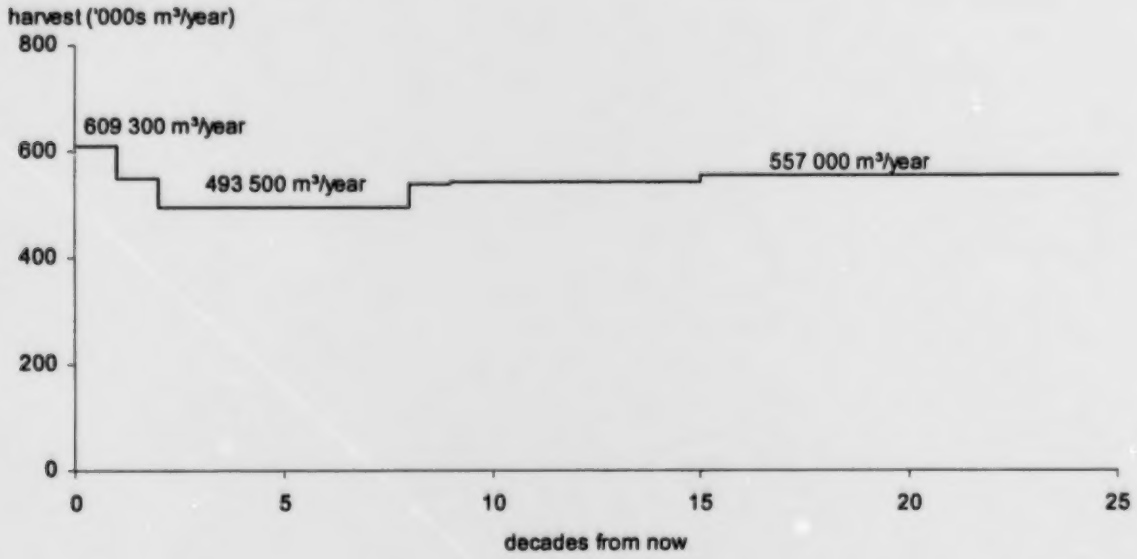


Figure 8. Base case harvest forecast for the Arrow TSA, 2000.

Harvest forecast
The flow of potential timber harvests over time. A harvest forecast is usually a measure of the maximum timber supply that can be realized over time for a specified land base and set of management practices. It is a result of forest planning models and is affected by the size and productivity of the land base, the current growing stock, and management objectives, constraints and assumptions.

Sensitivity analysis
A process that examines how uncertainty in data and management assumptions affect timber supply.

Long-term harvest level
A harvest level that can be maintained indefinitely given a particular forest management regime (which defines the timber harvesting land base, and objectives and guidelines for non-timber values) and estimates of timber growth and yield.

4 Results

Several harvest forecasts are possible for the Arrow TSA within the current management regime as described in previous sections. Prior to selecting the base case, a number of forecasts were developed to analyse the potential timber supply for the Arrow TSA. Figure 9 presents some of these forecasts, and the following paragraphs describe how the alternative forecasts were evaluated, and how the final selection of the base case harvest forecast was made.

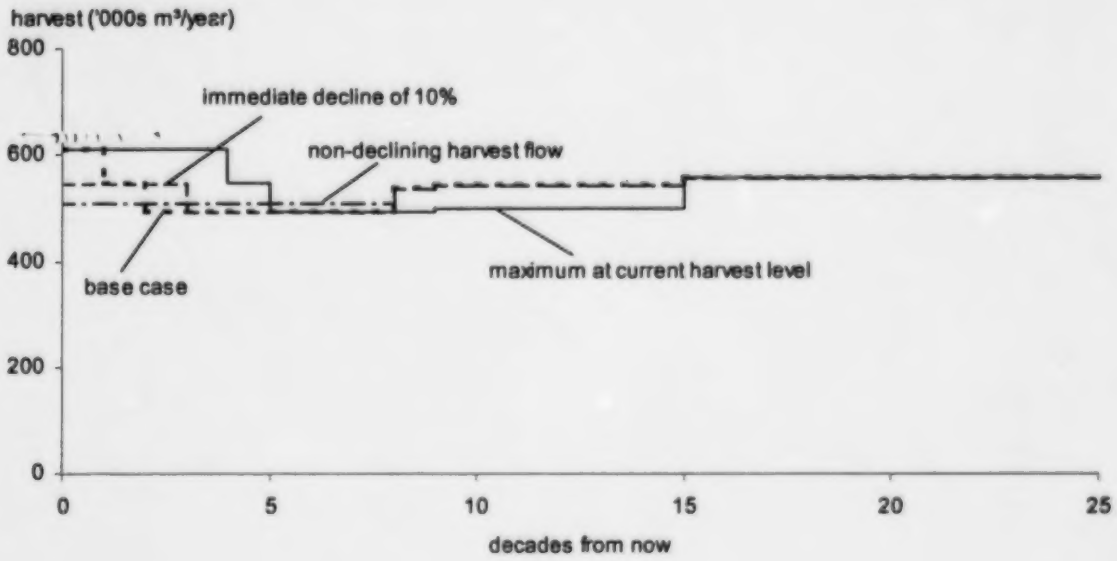


Figure 9. Alternative harvest flows — Arrow TSA, 2000.

One forecast tested the feasibility of having a non-declining harvest flow. The initial harvest level for this forecast was 511 280 cubic metres per year, 16% lower than the current harvest level. The harvest remained at this level until decade nine when it rose to 544 000 cubic metres per year and then followed the same projection as in the base case. For the first eight decades, this non-declining flow projected a total harvest of 28 430 cubic metres less than that obtainable in the base case.

A second forecast tested the feasibility of maintaining the current AAC for as long as possible without causing severe timber shortages in the future. Results show that it is possible to maintain the current AAC for four decades before declining to the base case level of 493 500 cubic metres per year. However, in this forecast, the harvest stays at this lower level until decade 15 because of the earlier more rapid depletion of the existing growing stock*. After decade 15, the forecast follows the same projection as in the base case. For the first fifteen decades, this forecast projects a total harvest of 6100 cubic metres less than that shown in the base case.

A third alternative tested the feasibility of lowering the harvest immediately by 10% to 548 370 cubic metres per year. It was possible to maintain this harvest level for three decades before following the same harvest projection as shown in the base case. For the first three decades, this forecast projects a total harvest of 6060 cubic metres less than that shown in the base case.

There is slightly more wood available for harvesting in the base case harvest forecast than there is in any of the other alternatives tested. The base case also provides for an orderly transition from harvesting existing natural stands to future managed stands. For these reasons, the harvest flow chosen as the base case was believed to be suitable as a basis for further analysis.

> ***Growing stock***
> *The volume estimate for all standing timber, at a particular time.*

4.1.1 Base case timber supply dynamics

As shown in Figure 6, the forest in both the timber harvesting land base and the non-timber harvesting land base is fairly well-distributed across all age classes with 62% at or above the minimum harvestable ages. Figure 10 shows that this distribution enables a smooth transition of harvest from existing natural stands to managed stands for the base case. The transition from existing to managed stands starts at the beginning of decade 8 and by decade 10 the contribution from managed stands comprises more than one-half the total harvest from the Arrow TSA. By decade 15, managed stands contribute about 90% of the harvest.

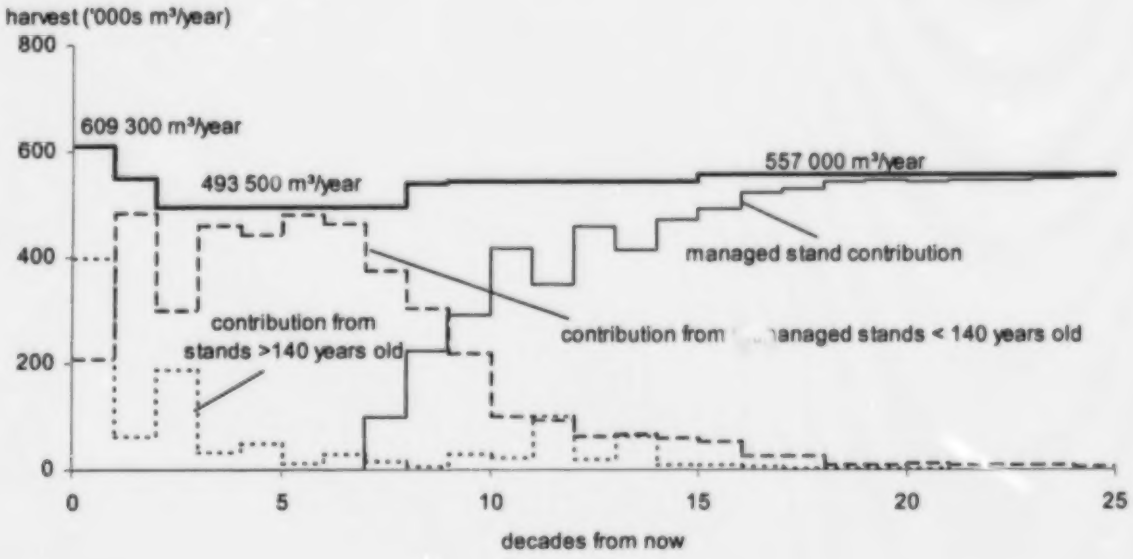


Figure 10. Harvest contribution from the unmanaged and managed stands — Arrow TSA, 2000.

4 Results

Figure 11 tracks the growing stock from managed stands and from existing natural stands. Some managed stands become merchantable as early as decade 5 but are not harvested until decade 8. The availability of merchantable timber from unmanaged stands allows the base case to approach the long-term harvest level by decade 9 even though at that time managed stands comprise only about 50% of the merchantable growing stock. Existing unmanaged stands still contribute to the merchantable growing stock well into the future largely because of the slow rate of harvest from retention and partial retention visual quality areas on the timber harvesting land base.

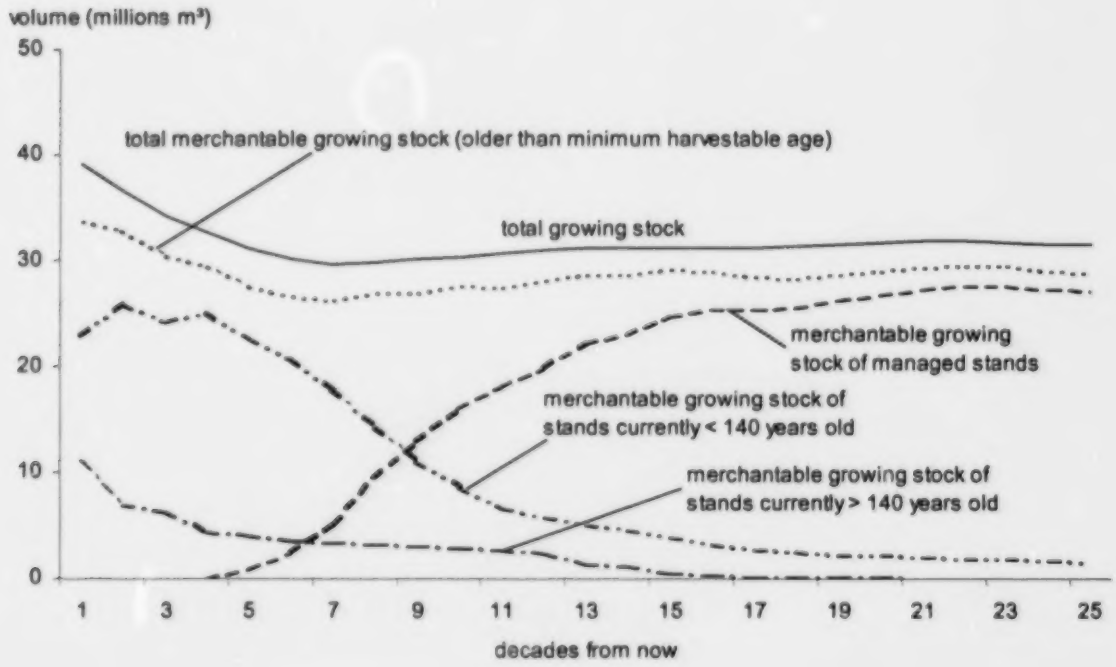


Figure 11. Total and merchantable growing stocks — Arrow TSA, 2000.

4.2 Average age, area, and volume harvested

Figure 12 tracks the change in the area-weighted average harvest age resulting from the base case forecast*. The pattern of harvested age over the first three periods reflects that highest harvest priority during modelling was given to stands furthest above their minimum harvestable age. The second period dip results because forest cover requirements* restrict harvests in older stands, while the third period rise reflects the increased availability of old stands when cover requirements are achieved. The two spikes between decades 10 and 15 are also explained by the harvest contribution of stands currently greater than 140 years old. From decade 15 onwards, the area-weighted average harvest age fluctuates around 110 years.

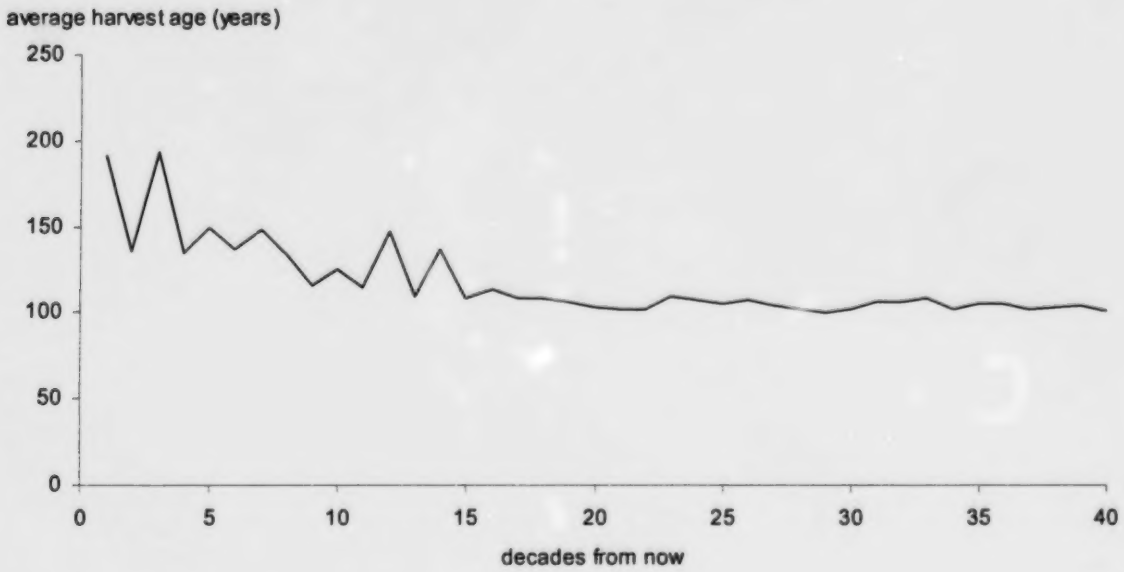


Figure 12. Average age of stands harvested over time — Arrow TSA base case, 2000.

Base case forecast
The timber supply forecast which illustrates the effect of current forest management practices on the timber supply using the best available information, and which forms the reference point for sensitivity analysis.

Forest cover requirements
Specify desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives. General adjacency and green-up guidelines are also specified using forest cover objectives.

4 Results

Figure 13 shows the average volume per hectare and average area harvested per year over the next 400 years under the base case harvest forecast. For the first 10 decades, while the timber supply is forecast to come mainly from unmanaged stands, the average volume per hectare varies from 300 to 350 cubic metres per hectare. After decade 12 when the timber supply is forecast to come from mainly from managed stands, the average volume per hectare is approximately 360 cubic metres per hectare. The area harvested for the first two decades is approximately 1850 hectares per year but this decreases as the harvest level decreases. The increase in the area harvested during decades nine to eleven is due to the lower productivity, lower volume stands being harvested at that time.

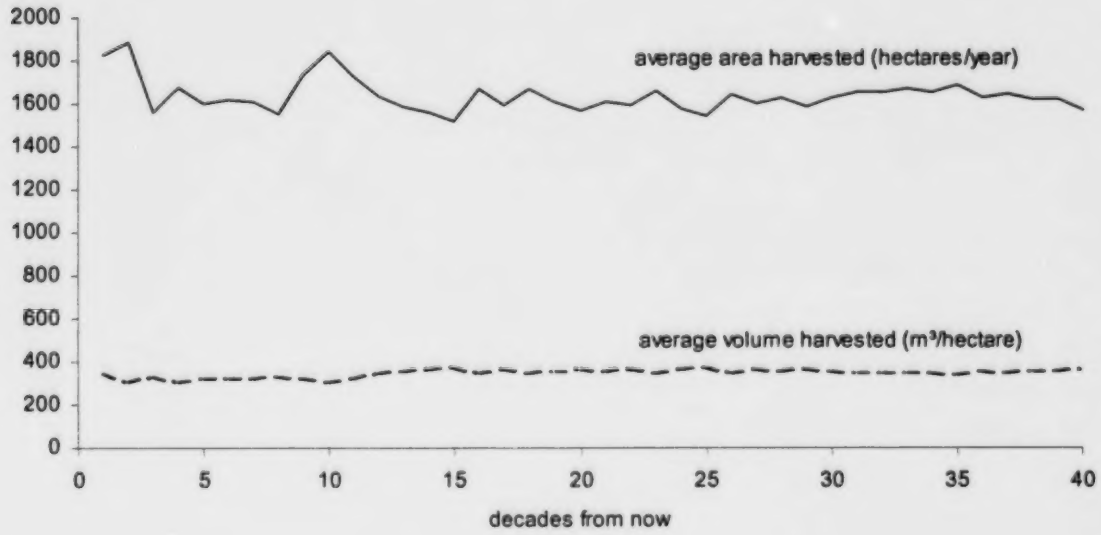


Figure 13. Average area harvested and average volume per hectare harvested over time — Arrow TSA base case, 2000.

4.3 Age class profile over time

The charts in Figure 14 show how the age composition of the forest both in the timber harvesting land base and in the non-timber harvesting land base of the Arrow TSA change over time under the base case harvest forecast. To make smaller differences discernible among the majority of classes, the vertical axis does not cover the full range of values in the last chart which displays the area distribution at 250 years from now. The oldest age class contains 150 000 hectares, which exceeds the vertical axis maximum as indicated by the arrow in the chart.

The current age class distribution shows that stands within the timber harvesting land base are fairly well distributed across all age classes. There is a significant amount of forest at 220 years old but only 3% of the forest in the timber harvesting land base is greater than 250 years old.

Outside of the timber harvesting land base the stands are also well distributed across all age classes with significant amounts currently between 50 and 100 years old. These younger stands are thought to originate from previous fires and pest activity. Similar to the timber harvesting land base, the non-timber harvesting land base has only 5% of the forest greater than 250 years old.

One consequence of the small proportion of stands greater than 250 years is that some of the old-growth requirements for landscape-level biodiversity are not met until the beginning of the fifth decade of the harvest forecast. This lack of older forest of some biogeoclimatic variants in some landscape units does not necessarily mean that merchantable forest cannot be harvested. The forest estate model used by the B.C. Forest Service reserves some of the older forest from the timber harvesting land base needed to meet old-growth objectives until stands outside the timber harvesting land base can meet the requirements. There is a substantial area close to the 250-year threshold which can be reserved to meet old-growth requirements. Since 62% of forest on the timber harvesting land base is currently eligible for harvesting, there are sufficient merchantable stands available to meet the harvest forecast during the waiting period. Reserving of stands for a long time extends the period over which existing stands are harvested, and results in small fluctuations around average volume and area harvested into the long term.

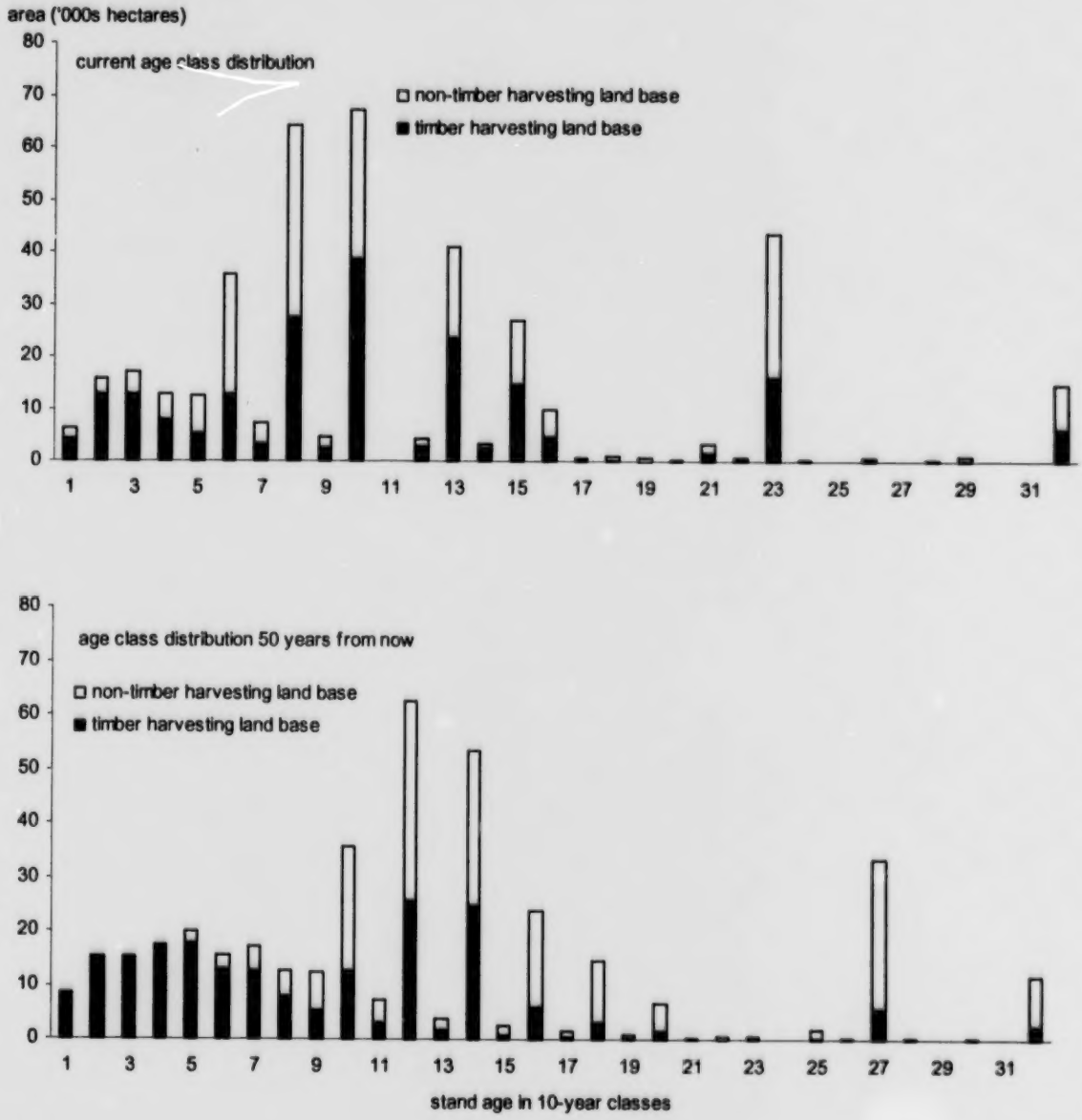


Figure 14. Changes in age composition on the productive land base over time — Arrow TSA base case, 2000.
(continued)

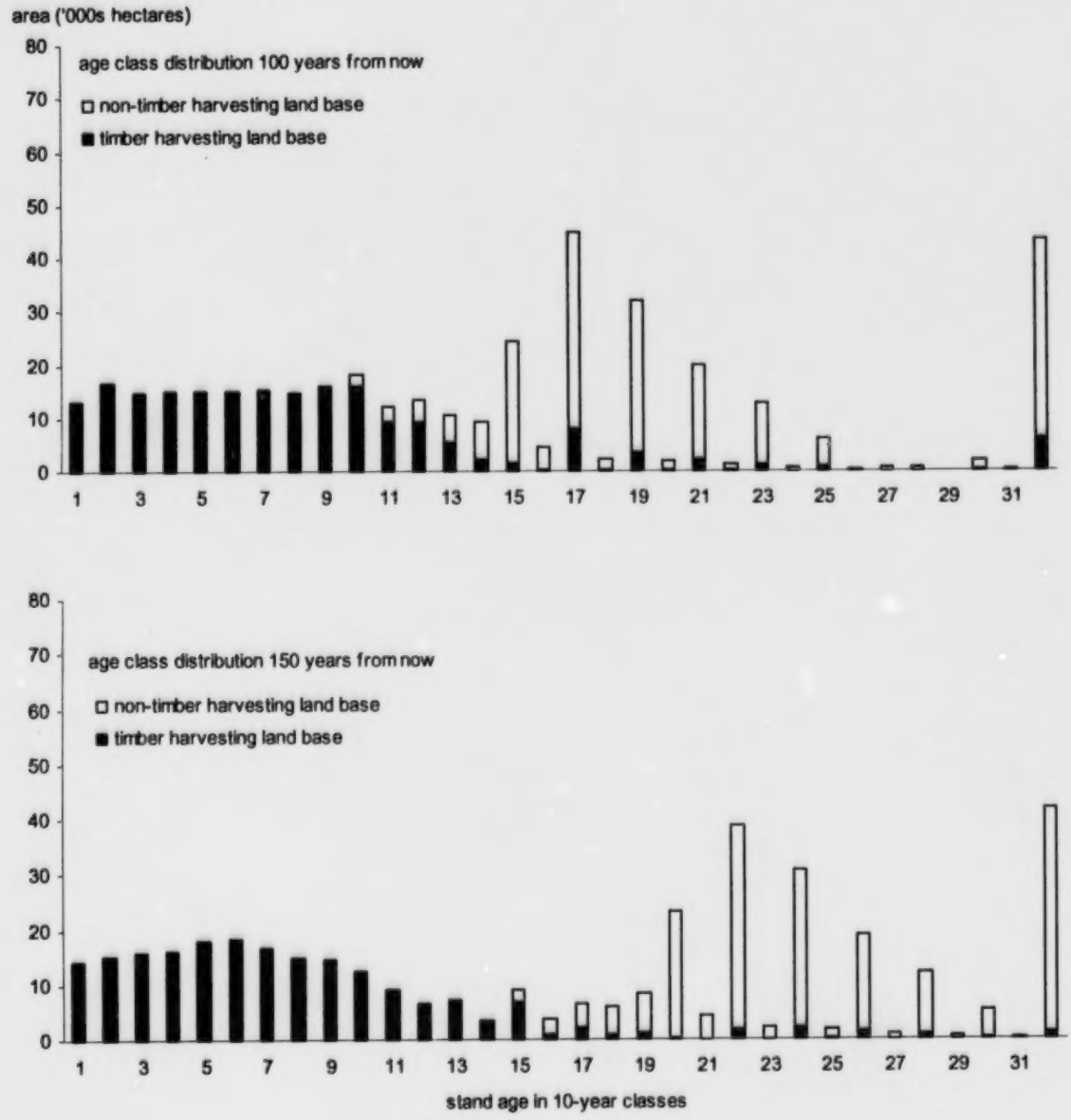


Figure 14. Changes in age composition on the productive land base over time — Arrow TSA base case, 2000.
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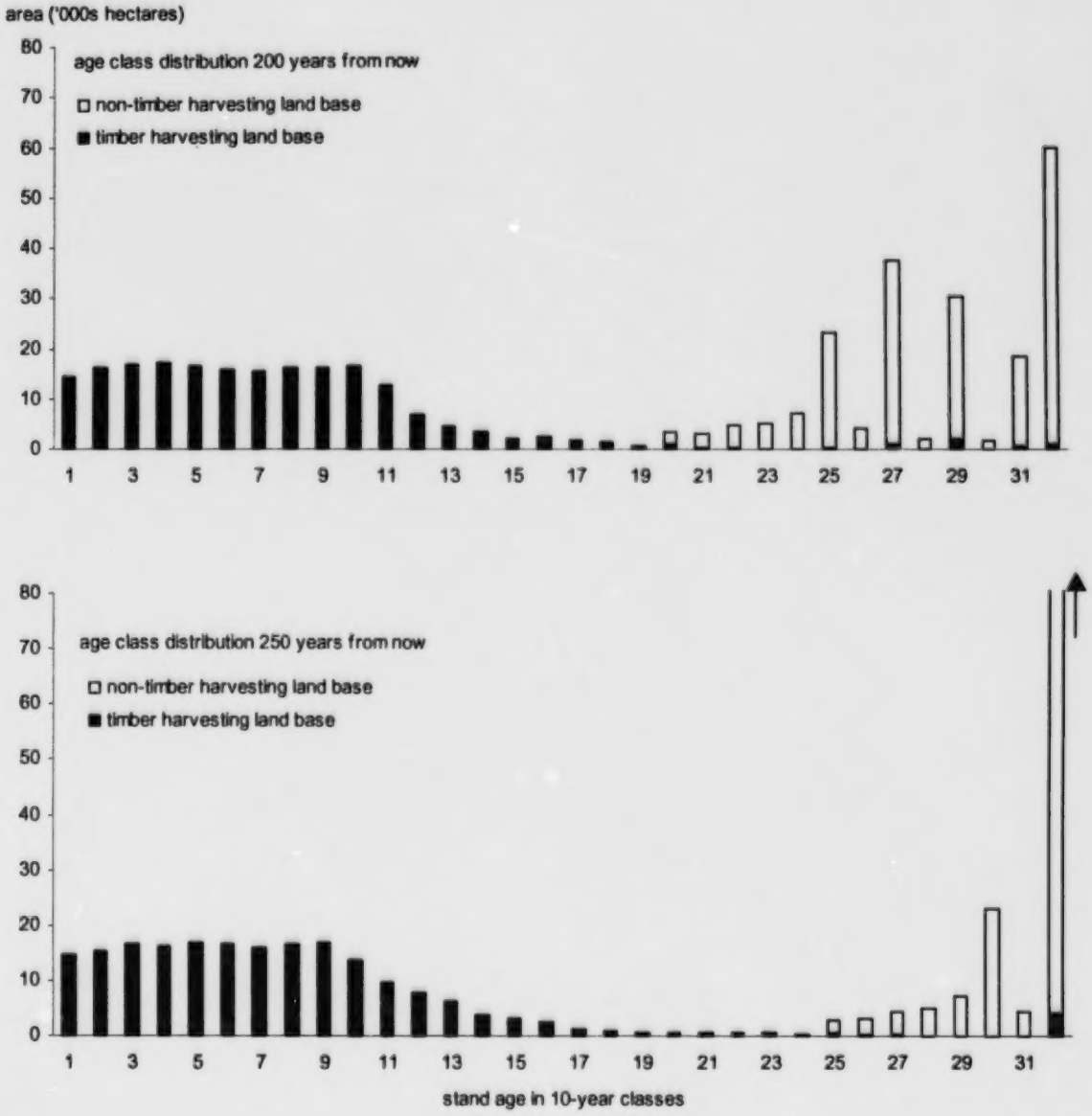

Figure 14. Changes in age composition on the productive land base over time — Arrow TSA base case, 2000.
(concluded)

5 Timber Supply Sensitivity Analyses

The best available information on forest inventories and management practices is used to analyse the timber supply implications of continuing with current management. However, forest management is a complicated endeavour that must account for diverse and changing human values, the dynamics of complex ecosystems, and fluctuating and uncertain economic factors. As well, forests grow quite slowly in terms of human time spans, which means that decisions we make today have not only short-term but also long-term effects. In such a context, we cannot be certain that all the data accurately reflect the current state of all values in the forest, how the forest will change, or how our management activities will affect the forest.

One important way to deal with this uncertainty is to revise plans and analyses frequently to ensure they incorporate up-to-date information and knowledge. Frequent planning and decision–making can help minimize any negative effects that may occur if decisions are based on inaccurate information. Frequent revision can also ensure that opportunities that become apparent from new information are not missed.

Another important way of dealing with uncertainty is to assess how values of interest, for example, timber supply, could change if the information used in the analysis is not accurate. Sensitivity analysis is one way of evaluating how uncertainty could affect analysis results, and ultimately decision-making. Sensitivity analysis can highlight that fairly small uncertainties about some variables could have large effects on timber supply projections, or conversely that fairly large inaccuracies in others could have negligible effects. Also, sensitivity analysis could show that some variables affect timber supply more in the short term than in the long term, while others have the opposite effect. It can highlight priorities for collecting information for future analyses, and show which variables, and associated uncertainties, have the most significance for decisions. Sensitivity analysis can clarify whether current best estimates provide a safe basis for decisions, or whether high uncertainty about important variables means more conservative decisions may be wiser.

In this section, results of several sensitivity analyses are discussed. Sensitivity analyses are intended primarily to test the relative change (i.e., high versus low sensitivity) in the harvest forecast resulting from changes in forest management assumptions and data used in the base case.

5.1 Uncertainty in the estimated area of the timber harvesting land base

Uncertainty in the estimated size of the timber harvesting land base is due to factors such as fluctuations in timber prices, changes in harvesting and milling technology and land-use decisions.

Another factor is the uncertainty around the use of regional or provincial averages in defining the land base when localized data are not available. For example, detailed local stream inventories were not available for the Arrow TSA, so an automated classification system was used to estimate stream category and thus land base reductions for riparian reserves.

Currently it is not possible to assess whether the timber harvesting land base has been over- or under-estimated, so two sensitivity analyses were performed. The first evaluates the outcome of shifting 20 306 hectares of the non-timber harvesting land base to the timber harvesting land base thereby increasing it by 10%. The second evaluates outcome of shifting 10% (20 296 hectares) of the timber harvesting land base to the non-timber harvesting land base.

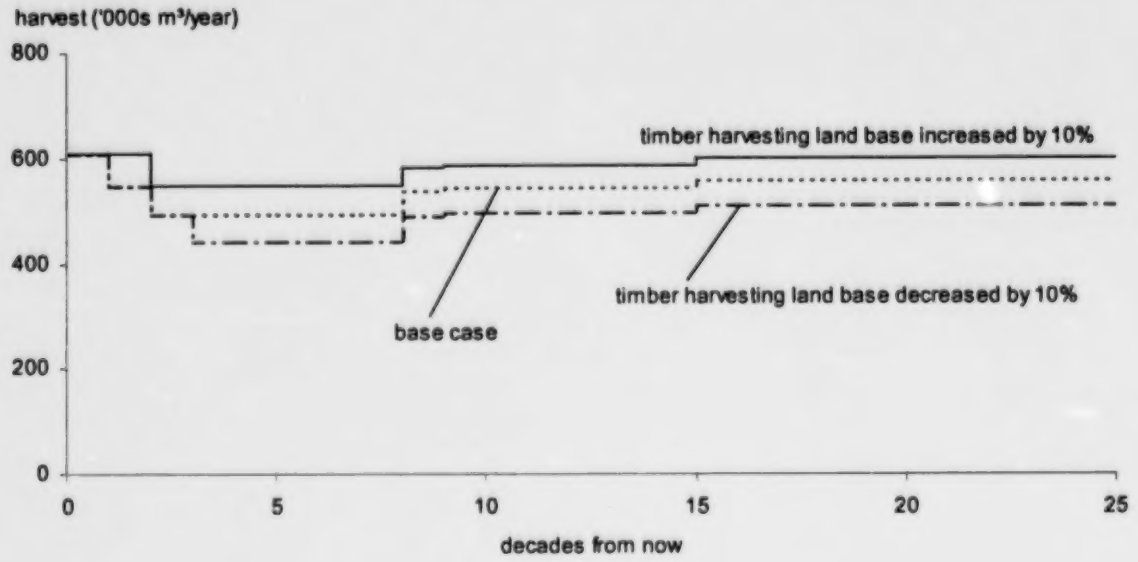

Figure 15. Land base sensitivity analysis — Arrow TSA, 2000.

The sensitivity analysis shows that if the base case over-estimated the timber harvesting land base, there is still sufficient area in older existing stands to support the harvest for one decade before declining to medium- and long-term levels approximately 10% lower than in the base case. If the timber harvesting land base is larger than in the base case, the transition to harvesting predominately second-growth managed stands is delayed. This delay results in older, higher volume stands being harvested during the transition period. The combination of higher volume second-growth stands and addition of more existing stands permits the initial harvest level to be maintained for two decades before following a similar pattern as shown for the base case to the new long-term harvest level of 600 000 cubic metres per year.

5.2 Uncertainty in the harvest contribution from the Slocan area

The Commission on Resources and Environment (CORE) identified a significant portion of the Slocan valley for more detailed local planning. This area incorporates the valley bottom and adjacent watershed units of the Slocan Lake and the Slocan River. Table 3 shows the categories of land in the Slocan CORE sector review area.

Table 3. Determination of the timber harvesting land base for the Slocan CORE sector review area

Total area (hectares)	78 993
Not managed by the B.C. Forest Service	16 569
Non-forest, non-commercial forest	13 321
Total forested area managed by the B.C. Forest Service	49 103
Forested area not contributing to timber harvesting	20 695
Current timber harvesting land base	28 408

This area represents 14% of the timber harvesting land base of the entire Arrow TSA and in the base case it contributes 14% (89 329 cubic metres per year) of the harvest in the first decade. The contribution from the Slocan area for the rest of the planning horizon varies from 15% to 8% of the base case harvest forecast. For various reasons, the actual harvest from this area during the past 12 years has been significantly less than that projected in the base case of this timber supply analysis. When the forest from a specific geographic location is projected to contribute to the harvest but is not fully harvested, the timber supply for the entire TSA is affected. Figure 16 shows the effect on total timber supply resulting from reduced levels of harvest from the Slocan area.

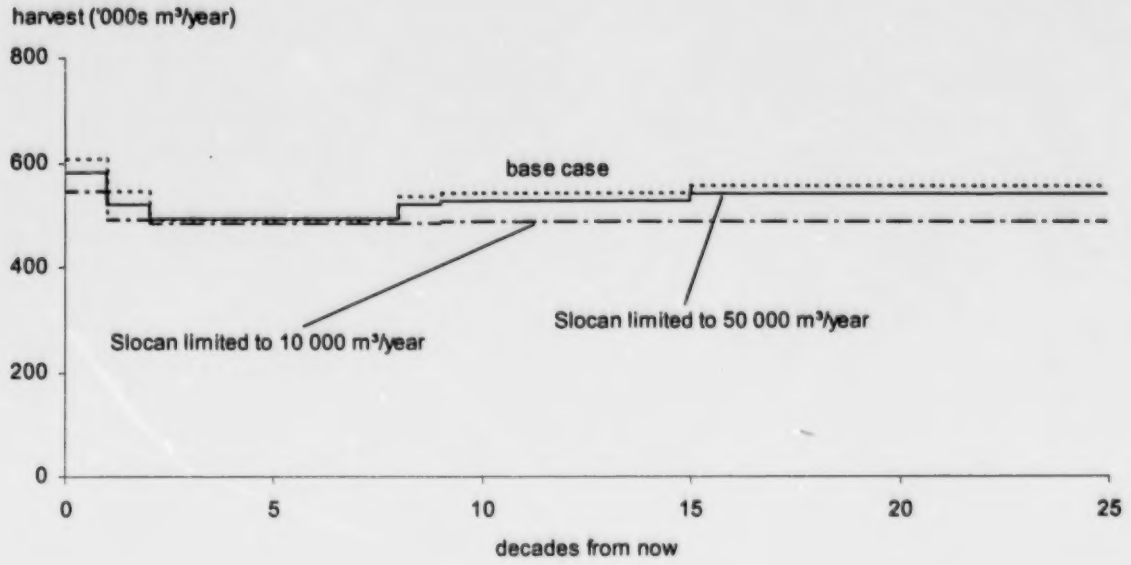

Figure 16. The effect of reduced levels of harvesting in the Slocan CORE sector review area — Arrow TSA, 2000.

When the harvest contribution from the Slocan is limited to 50 000 cubic metres per year, the initial harvest level attained from the Arrow TSA decreases to 581 280 cubic metres per year. From decades three to eight the harvest is the same as that in the base case but in the longer term the harvest is projected to be 16 000 cubic metres per year lower than in the base case. When the harvest contribution from the Slocan is limited to 10 000 cubic metres per year, the initial harvest level attained from the TSA decreases by 10% to 548 370 cubic metres per year. The long-term harvest level is projected to be 489 000 cubic metres per year, 12% lower than in the base case.

5.3 Uncertainty in the estimated time to green-up

Forest cover requirements for visual quality, wildlife habitat, water quality and adjacency applied in this analysis involve estimates of when stands will reach green-up conditions, expressed as the desired height of a stand (see Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis" for desired green-up heights for each management emphasis area). Green-up age, the age at which a stand exhibits the required height, was determined for the Arrow TSA by examining the height growth of regenerating stands in the Nelson Forest Region. Green-up tables for the forest regions of British Columbia are provided in *Age to green-up: using regeneration survey data*, Pollack et al., 2000. The green-up period includes both the green-up age and the regeneration delay*, or time taken to establish a stand after harvesting. Uncertainty about green-up period arises because the desired green-up condition (that is, tree height) may either exceed or fall short of actual needs, the period of stand establishment may vary, and variations in local stand growth from the regional average may result in stands reaching the desired condition sooner or later than estimated.

Regeneration delay
The period of time between harvesting and the date by which an area is occupied by a specified minimum number of acceptable well-spaced trees.

Figure 17 shows that timber supply in both the medium- and long-term is sensitive to an increase in the time to green-up. If green-up ages were actually 5 years more than estimated for the base case, timber supply would decrease to 444 180 cubic metres per year by the fourth decade. The long-term harvest level would be 483 000 cubic metres per year, about 13% lower than that of the base case

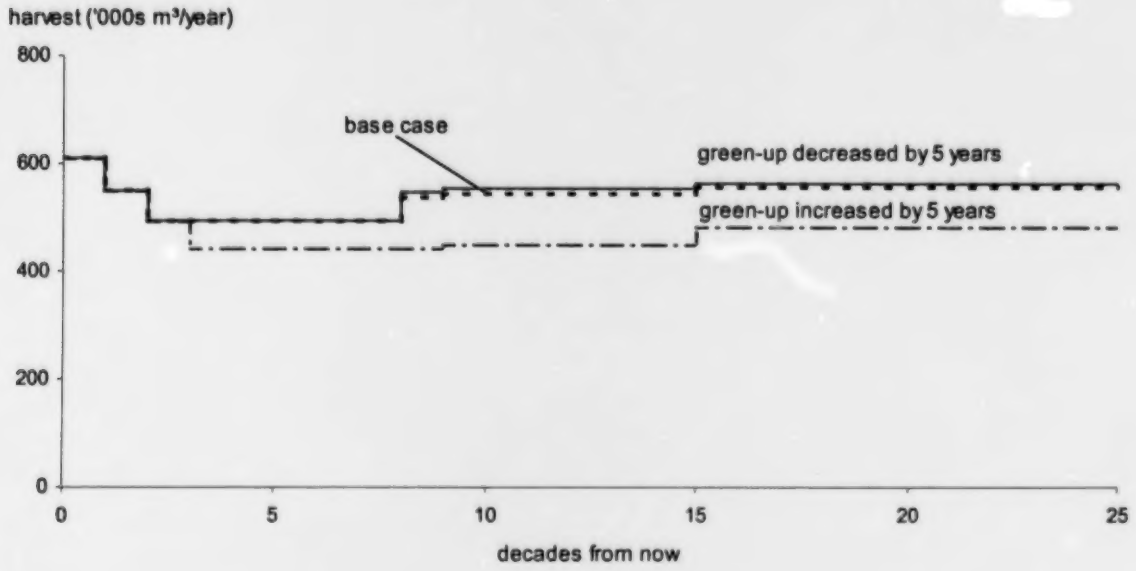

Figure 17. Harvest forecasts if green–up ages were either 5 years longer or shorter than in the base case — Arrow TSA, 2000.

If green-up ages were actually 5 years less than in the base case, harvest levels in the short- and medium-term would be the same. The slight increase in the long-term timber supply is due to the increase in the availability of timber in the partial retention* and retention VQO* management zones. The forest cover requirements limiting disturbance in these zones limit timber supply in the base case, and by making these requirements less restrictive in this sensitivity analysis, more timber is made available for harvest in the long term.

Partial retention VQO
Alterations may be visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity (see Visual quality objective).

Retention VQO
Alterations are not easy to see. Up to 5% of the visible landscape can be altered by harvesting activity (see Visual quality objective).

5.4 Uncertainty in the estimated existing stand yields

Timber volume estimates for existing unmanaged stands are subject to uncertainties in the forest inventory used to estimate timber volumes (i.e., estimated tree heights and stand ages), and the statistical process used to develop the equations for predicting forest growth and yield. Although no specific issues were identified during the inventory audit of the Arrow TSA, a standard sensitivity analysis was performed to test the potential effect on timber supply of uncertainty in the estimates of existing unmanaged stand volumes. The results of decreasing and increasing existing unmanaged stand yield estimates by 10% are presented in Figure 18.

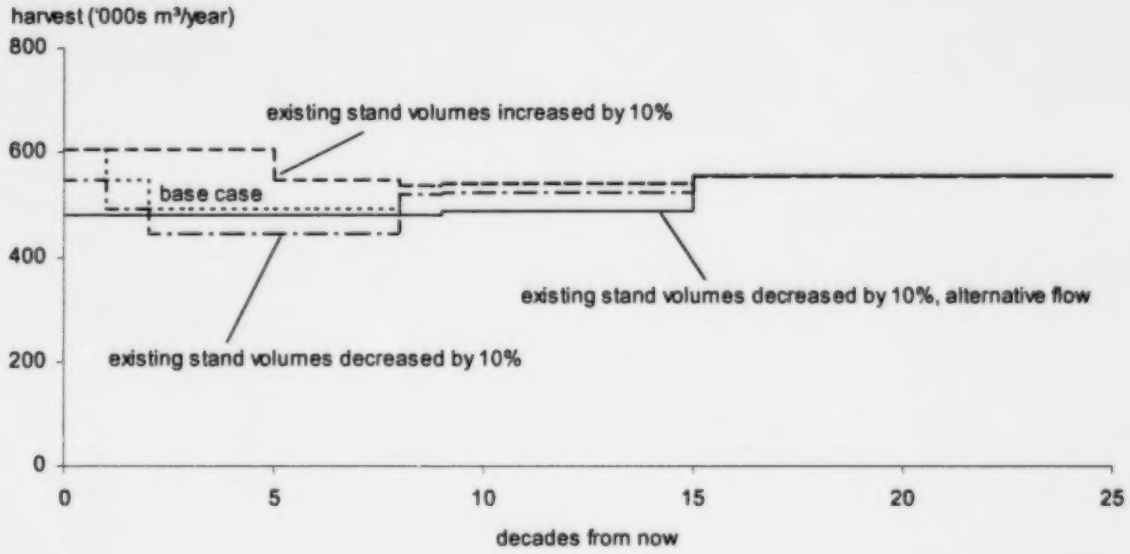

Figure 18. The effect on the harvest forecast of increasing and decreasing volume estimates for existing unmanaged stands by 10% — Arrow TSA, 2000.

Figure 18 shows two alternate harvest forecasts if existing unmanaged stand volumes are decreased by 10%. Using harvest flow guidelines similar to those used to establish the base case, an initial harvest level of 548 370 cubic metres per year (10% lower than the current AAC) is possible. This harvest then declines to 446 280 cubic metres per year by decade three before rising to the same long-term level as in the base case. Under a non-declining harvest flow, the initial harvest would be 481 280 cubic metres per year, 21% or 128 000 cubic metres less than the base case. The harvest remains at this level until decade 15 before rising to the base case long-term level.

When existing unmanaged stand volumes are increased by 10%, the increased volume allows the initial harvest level to be maintained for five decades before declining to a level that is 10% higher than the base case level. After decade eight the harvest level is the same as that obtained in the base case.

5.5 Uncertainty in estimated managed stand yields

Uncertainty in volume estimates for managed stands exists for the same reasons listed for estimated existing stand yields (inaccuracies in the forest inventory and the growth and yield models), but also because of the limited experience and data that is available for regenerated managed stands in B.C. There is also uncertainty around the site productivity assigned to older unmanaged stands relative to the site productivity expressed by the stands after they regenerate. This issue is examined in Section 5.7, "Uncertainty in the productivity of current old-growth sites after harvest."

As with existing unmanaged stand yield estimates, there are no specific issues directly related to managed stand yield estimation, other than site productivity estimates. However, Arrow Forest District staff have identified that the juvenile spacing* program may be at risk if funding levels are reduced in the future. A comparison of yield tables indicated that expected stand volumes with twice the number of stems as projected in the base case are on average about 12 cubic metres per hectare less than those for spaced stands at minimum harvestable ages. Beyond minimum harvestable ages, volumes in higher density stands approach and usually surpass volumes for spaced stands. Given that there are only small differences in expected volumes at harvest (i.e., minimum harvestable ages), there appears to be little risk to the base case forecast at least in the context of these uncertainties in silviculture. However, the change in the silvicultural prescriptions will likely affect the number of expected stems, piece size and quality of the harvested timber.

Factors other than the silvicultural regime could affect future yields, so a standard sensitivity analysis, in which managed stands yields were increased and decreased by 10%, was performed. The results are presented in Figure 19. When yields are decreased by 10%, the harvest decreases to 491 280 cubic metres per year by the third decade as in the base case, but remains at this level for the remainder of the planning horizon. The slight increase seen on the graph at decade nine is because of the anticipated decrease in the unsalvaged losses at that time (see Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis" for details on unsalvaged losses). When yields are increased by 10%, the long-term harvest level increases by 10% to 609 300 cubic metres per year, the same as the initial harvest level.

Juvenile spacing
A silvicultural treatment to reduce the number of trees in young stands, often carried out before the stems removed are large enough to be used or sold as a forest product. Prevents stagnation and improves growing conditions for the remaining crop trees so that at final harvest the end-product quality and value is increased.

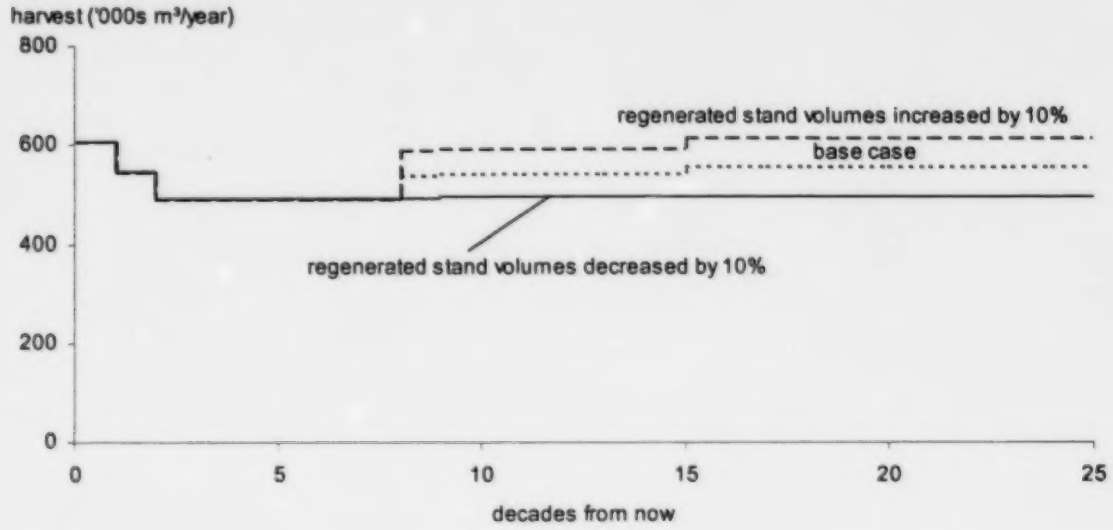

Figure 19. The effect on the harvest forecast of increasing and decreasing volume estimates for managed stands by 10% — Arrow TSA, 2000.

5.6 Uncertainty in volume reductions caused by root rot in regenerated Douglas-fir stands

Armillaria ostoyae is a fungus which causes root disease and subsequent tree mortality in many tree species in southern British Columbia. Staff in the Arrow Forest District have noted the presence of *Armillaria* in the Interior-Cedar Hemlock (ICH) and Interior Douglas-fir (IDF) biogeoclimatic zones. It has been suggested that activities such as partial harvesting increase the spread of the fungus, and staff are concerned that the estimated volume of regenerated Douglas-fir stands in partial-harvest areas may be overestimated in the base case. In the base case, the estimated volume of managed stands are adjusted using provincial average operational adjustment factors (OAFs). The factor used to adjust the volume to account for agents, such as root rot, which kill trees slowly over time (OAF2) was 5%. The effect of this OAF is to reduce the estimated volume gradually over time so that by age 100 years the volume is reduced by 5%, and even more than 5% beyond 100 years.

There are no detailed studies to quantify the extent and effect of root rot in regenerated stands, however, Table 4 shows the adjustments applied in this sensitivity analysis to examine the possible magnitude of the problem. There are presently only 9571 hectares of regenerated stands with a significant component of Douglas-fir, however, this analysis projects that in the long term about 73% of the timber harvesting land base will have such stands.

Table 4. OAFs used to examine the effect of root rot in regenerated stands — Arrow TSA, 2000

Analysis unit	Base case OAF2 (%)	Adjusted OAF2 (%)
130 Existing regenerated fir/spruce, all sites	5	20
231 Future regenerated fir/spruce, good site	5	20
232 Future regenerated fir/spruce, medium site	5	20
233 Future regenerated fir/spruce, poor site	5	20
112 Existing regenerated fir/pine/cedar, medium site	5	20
113 Existing regenerated fir/pine/cedar, poor site	5	20
211 Future regenerated fir/pine/cedar, good site	5	20
212 Future regenerated fir/pine/cedar, medium site	5	20
213 Future regenerated fir/pine/spruce, poor site	5	20
171 Existing regenerated pine/fir/spruce, good site	5	15
172 Existing regenerated pine/fir/spruce, medium site	5	15
173 Existing regenerated pine/fir/spruce, poor site	5	15
271 Future regenerated pine/fir/spruce, good site	5	15
272 Future regenerated pine/fir/spruce, medium site	5	15
273 Future regenerated pine/fir/spruce, poor site	5	15

Results of the root rot sensitivity analysis are presented in Figure 20. The graph shows that the harvest level declines to 466 280 cubic metres per year by decade 4. The long-term harvest level is only slightly higher at 485 000 cubic metres per year, 15.9% lower than in the base case.

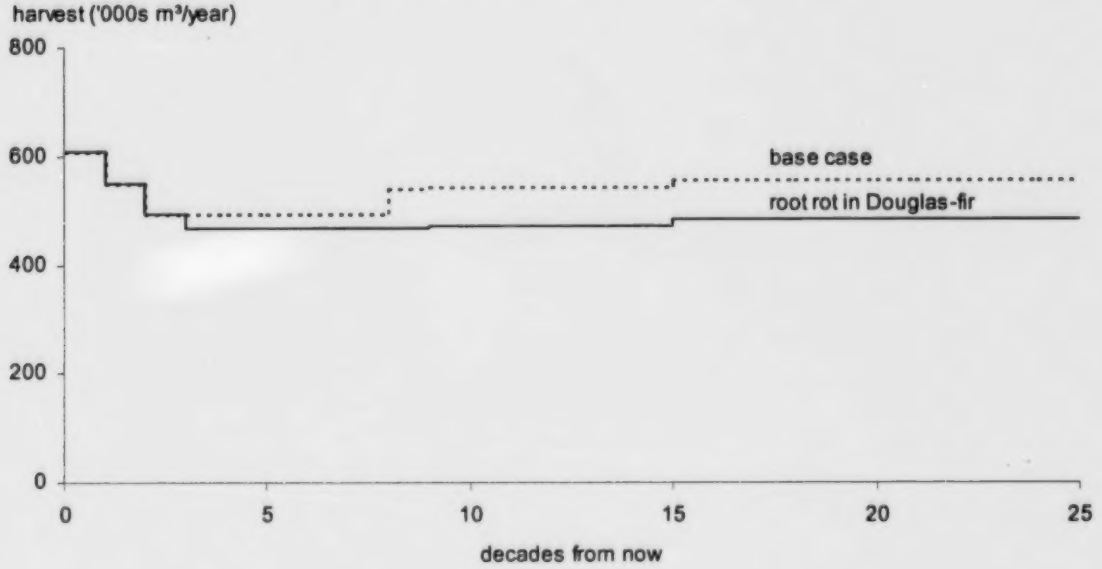

Figure 20. Harvest forecast based on OAFs adjusted to reflect increased incidence of root rot — Arrow TSA, 2000.

5.7 Uncertainty in the productivity of current old-growth sites after harvest

The productivity of a site largely determines how quickly trees will grow. It therefore affects the timber volumes in regenerated stands, the time to reach green-up and the age at which stands will reach merchantable size. The most accurate estimates of site productivity come from stands between 30 and 150 years old. At ages less than about 30 years a temporary increase or decrease in growth due to factors such as a post-harvest flush of nutrients or an unusual drought year can affect the overall productivity estimated for the stand. At older ages, site productivity estimates may be incorrect because tree heights do not represent actual production — for example due to top breakage — and it is very difficult to determine ages of old trees accurately. The results of recent province-wide research suggest that the estimated productivity of sites currently occupied by old-growth stands may be significantly underestimated. Two Old Growth Site Index (OGSI) studies applicable to timber supply forecasting are:

- *Site index adjustments for old-growth stands based on paired plots* (Nussbaum 1998). Data were obtained from paired plots installed in old-growth stands and adjacent logged and regenerated stands of the same productivity. Site index* was estimated for both and comparisons were made. Results are available for coastal Douglas-fir, lodgepole pine, and interior spruce.

> ***Site index***
> *A measure of site productivity. The indices are reported as the average height, in metres, that the tallest trees in a stand are expected to achieve at 50 years (age is measured at 1.3 metres above the ground). Site index curves have been developed for British Columbia's major commercial tree species.*

- *Site index adjustments for old-growth stands based on veteran trees* (Nigh 1998). The objective of the study was to develop site index adjustments for species not covered by the paired-plot project. The data for this study came from temporary and permanent plots with a veteran and main stand component. The site indices for the two components were estimated and an adjustment equation for each species was derived using linear regression analysis. The results of the study are considered less reliable than those from the paired-plot study.

Use of the results of the aforementioned studies is of particular interest to the Arrow TSA, as stands older than 140 years comprise 15% of the timber harvesting land base. To test the sensitivity of the base case harvest forecast to uncertainty about site index estimates, site indices of these older stands were adjusted using either the paired plot or veteran-tree results, whichever was applicable. Timber supply analysis inputs affected by changes in estimated future productivity (managed stand volume estimates, green-up ages and minimum harvestable age) were recalculated based on average site productivity. Table 5 compares the average forest inventory-based site index for each old-growth analysis unit to those defined using the OGSI adjustments.

Table 5. Average analysis unit site index based on forest inventory and OGSI information — Arrow TSA, 2000

Analysis unit	Area (hectares)	Inventory site index	Adjusted site index
Fir/larch medium	1 516	19.5	20.3
Fir/larch poor	3 685	15.1	17.6
Cedar/hemlock medium	1 006	18.0	20.7
Cedar/hemlock poor	9 767	13.0	20.7
Balsam medium	1 961	13.9	16.7
Balsam poor	6 328	10.8	14.9
Spruce medium	2 103	17.7	20.9
Spruce poor	4 835	10.9	19.6
Pine	809	13.9	19.3

Results of the OGSI sensitivity analysis are presented in Figure 21. The graph shows that the harvest level could be 9.3% higher than the base case during decades 9 to 15 and 6.9% higher in the longer term. Site index adjustments are not included in the base case since there is little local site productivity data or long-term monitoring of regenerated stands to support the adjustments. However, the results of the sensitivity analysis do provide insight into the possible trends associated with site productivity estimates for the Arrow TSA and indicate that long-term timber supply is likely higher than currently estimated.

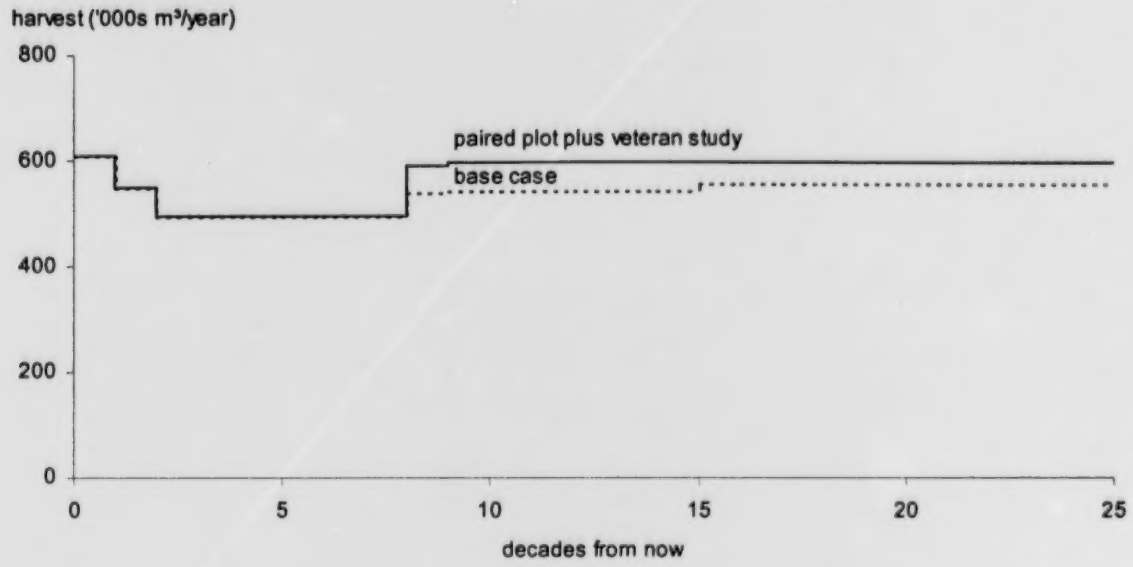

Figure 21. Harvest forecast based on OGSI (paired plot and veteran studies) site index adjustments — Arrow TSA, 2000.

5.8 Uncertainty in forest cover requirements for visual quality

Visual quality objectives (VQOs)* may be stated as the proportion of an area on which forestry activities may be visible. The B.C. Forest Service, Forest Practices Branch, has provided a range of allowable visible disturbance for each visual quality class (VQC), stated as maximum per cent area younger than green-up age. Different disturbance limits are recommended for each VQC (for instance, partial retention) depending on the visual absorption capacity of the terrain and forest in the area. Table 6 shows the per cent allowable disturbance for each of the VQCs by visual absorption capacity.

Table 6. Maximum allowable disturbance levels for various visual quality classes

	Visual absorption capacity (% visibly obvious forestry activity)		
Visual quality class	**Low**	**Medium**	**High**
Retention	1.1	3	5
Partial retention	5.1	10	15
Modification	15.1	20	25

Visual quality objective (VQO)
Defines a level of acceptable landscape alteration resulting from timber harvesting and other activities. A number of visual quality classes have been defined on the basis of the maximum amount of alteration permitted.

In the base case the allowable disturbance used assumed a high visual absorption capacity for all VQCs. Partial retention management prescriptions applied to 31% of the timber harvesting land base, and a further 5% were considered for retention management. Uncertainty about forest cover objectives may arise from inventory and classification of land into visual absorption capacity classes, from estimates of how well different disturbance limits may meet visual objectives, and from estimates of how non-harvestable forest may contribute to visual quality.

Figure 22 shows the effect on timber supply if the visual absorption capacity were medium and low for all visual quality classes in the Arrow TSA. If all visual management areas were considered to have low visual absorption capacities, timber supply would decrease to 377 000 cubic metres per year by decade six and the long-term timber supply would be 26% lower than that of the base case. With medium visual absorption capacities, the long-term timber supply would be about 10% lower than that of the base case.

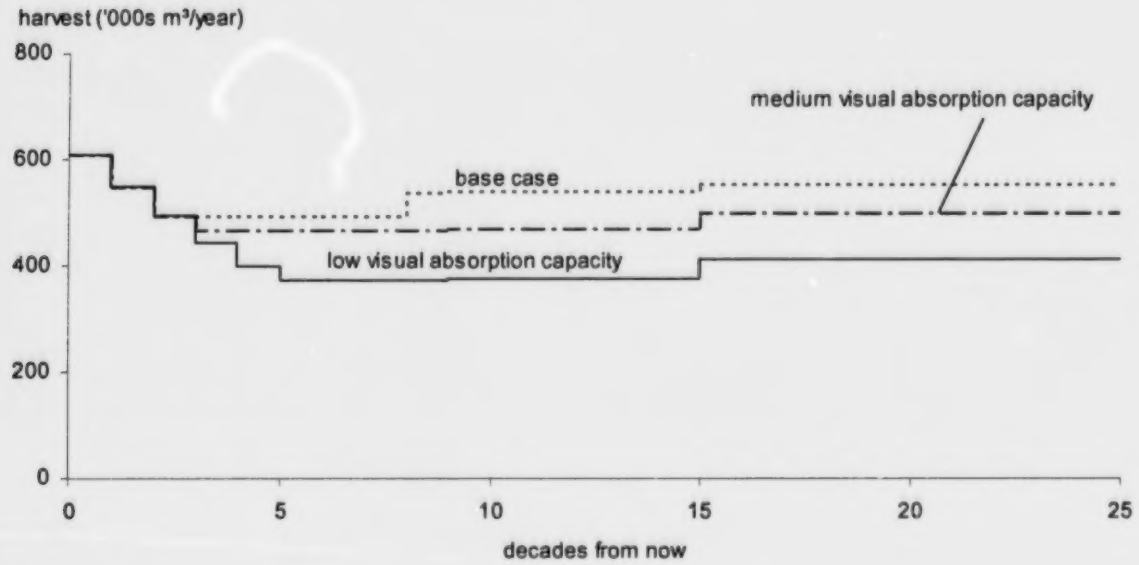

Figure 22. Timber supply projections if forest cover objectives for medium and low visual absorption capacities were applied to all visual quality classes — Arrow TSA, 2000.

5 Timber Supply Sensitivity Analyses

In the base case all the separate parcels of land (visual polygons) of a particular VQC in each landscape unit were grouped and treated as one contiguous block of land. The forest cover requirements for the VQC were then applied to the entire block in each landscape unit. This approach simplifies the analysis since green-up ages are calculated for the blocks rather than the separate polygons. In practice, the forest cover requirements are applied to the visual polygons within the landscape unit. In the Arrow TSA there were approximately 800 such polygons which were further subdivided into 1320 zones because visual polygons were also managed for other objectives. Figure 23 shows the timber supply projection when the forest cover requirements for the VQCs were applied to each of the zones. All zones were assumed to have high visual absorption capacities.

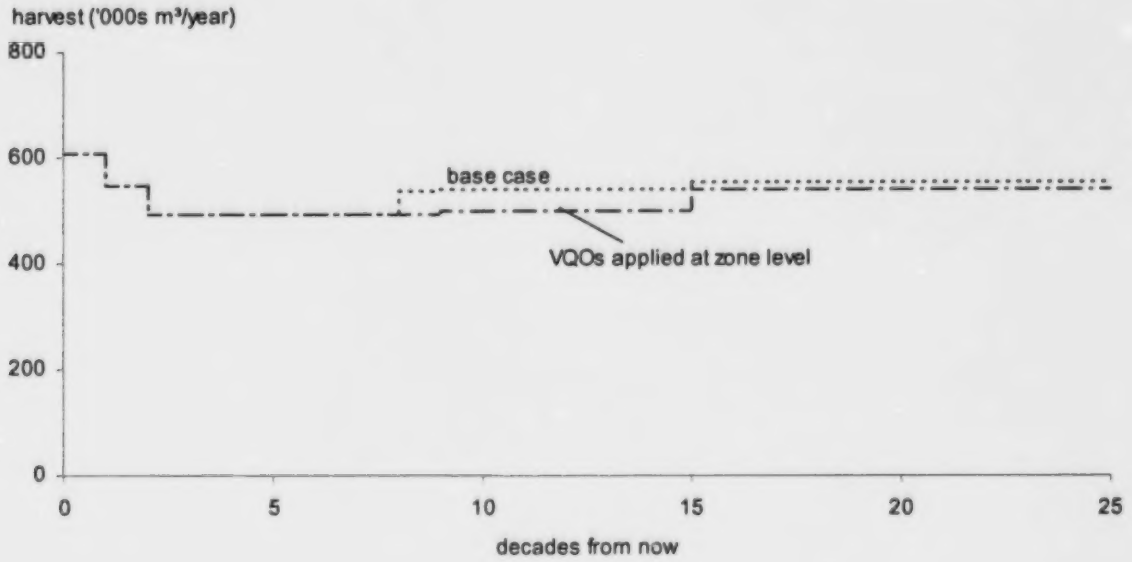

Figure 23. Timber supply projection when forest cover objectives for all visual quality classes are applied at the zone level — Arrow TSA, 2000.

5.9 Uncertainty in the growth rate of seedlings from seed orchards

Reforestation following harvesting is required by law in British Columbia and reforesting with seedlings grown from selected seed (if available) is a requirement of the *Forest Practices Code*. For the past 40 years this province was involved in a process of breeding trees with desirable traits such as faster growth, better stem and wood quality, and resistance to diseases and insect attack. Tree breeding offers potential gains in timber supply forecasting through increases in growth rate that may reduce minimum harvestable ages, increase volume at time of harvest, and ease adjacency constraints through faster green-up. Seed selected through the tree breeding program can be obtained from seed orchards located throughout the province.

In this sensitivity analysis it was assumed that 93% of the seedlings planted in the future originated from seed obtained from seed orchards. Seed for western red-cedar, which accounts for 7% of the reforestation activities in the Arrow TSA, is not projected to be available from orchards. White spruce seedlings were expected to grow 20.5% faster than ecologically comparable natural stand seed. Similarly, lodgepole pine was expected to grow 8.2% faster, and Douglas-fir 10.2% faster than assumed in the base case. The growth rate increases stated here are applicable only for a certain range in site productivity and for a specific age (80 years for spruce, and 60 years for pine and fir). For example, a spruce stand originating from a seed orchard and planted on a medium productivity site is projected to have 20.5% more volume at age 80 years than a similar stand not originating from a seed orchard. However, the difference in volume yield decreases after 80 years to almost no volume difference between the two stands by age 200 years. Figure 24 shows that the long-term harvest level could increase by 5.7% if reforestation in the Arrow TSA was accomplished using seed from seed orchards. This is lower than the gains mentioned above because, in this analysis, the actual harvest ages were seldom at age 80 years for spruce or 60 years for pine and fir.

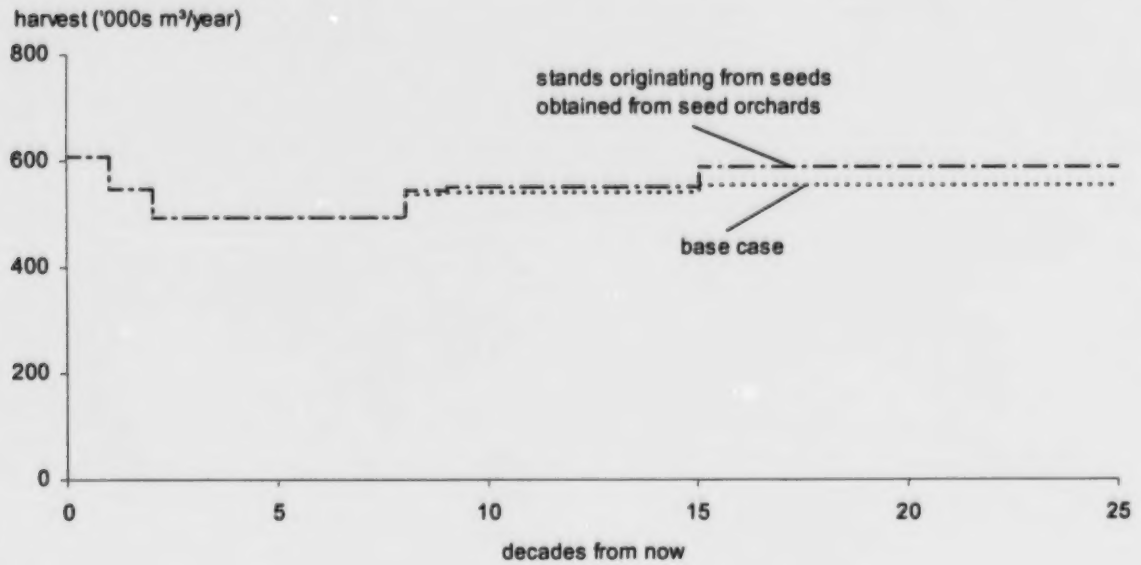

Figure 24. Harvest forecast if seeds from seed orchards were used for reforestation — Arrow TSA, 2000.

5.10 Uncertainty in the estimated minimum harvestable ages

Minimum harvestable age is an estimate of the time needed for a stand to reach a merchantable condition. The time at which stands will become merchantable is highly uncertain. This is partly because of uncertainty about the growth of regenerated stands, but more importantly because we cannot foresee future conditions that will determine merchantability.

For this analysis, minimum harvestable ages were estimated as the age at which stands accumulated an average merchantable volume of 150 cubic metres per hectare and when the average stem diameter at breast height was 25 centimetres. These minimum stand volume criteria are described in detail in Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis", and apply to both managed and unmanaged stands. These criteria were chosen to ensure that only stands with sufficient merchantable volume would be considered available for harvest. For all analysis units* in this TSA, achieving the volume criterion took longer than achieving the diameter criterion. The minimum harvestable ages are minimums; in this analysis stands may be harvested at older, but not younger, ages. In fact, many stands are harvested at ages beyond the minimum in order to meet management objectives and forest cover requirements. Minimum harvestable ages are meant to approximate the timing of merchantability, and are not legal or policy requirements.

Figure 25 shows how timber supply would change if stands in fact become merchantable either earlier or later than assumed for the base case.

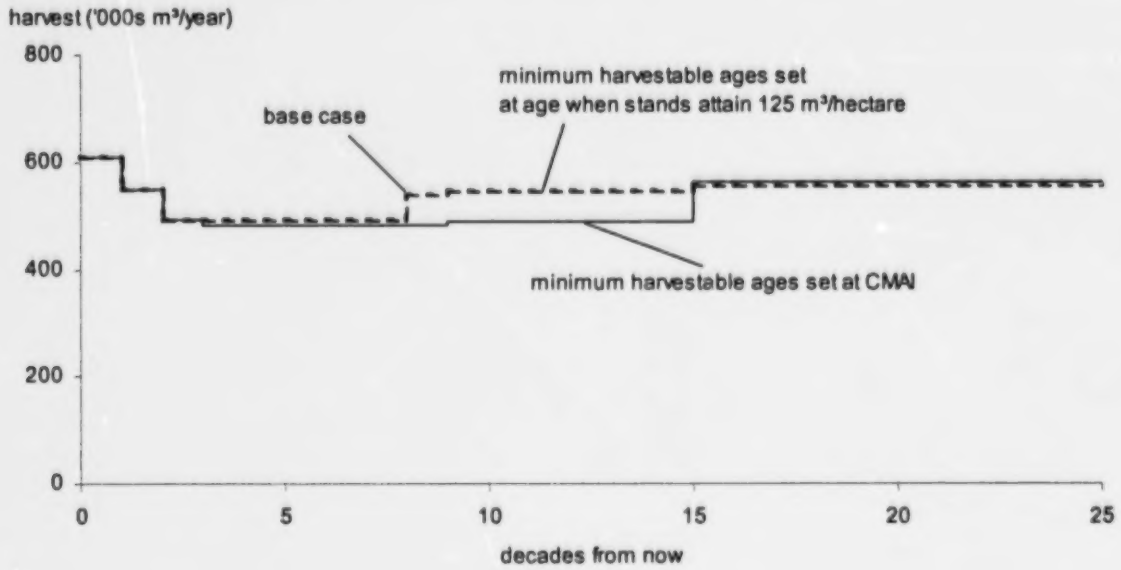

Figure 25. Harvest forecasts if minimum harvestable ages are younger or older than the base case — Arrow TSA, 2000.

Analysis unit
A grouping of types of forest - for example, by species, site productivity, silvicultural treatment, age, and or location, done to simplify analysis and generation of timber yield tables.

If minimum harvestable ages were set at the age when stands attained a merchantable volume of 125 cubic metres per hectare, results indicate that timber supply would be the same as in the base case. Most stands in this TSA attained a volume of 125 cubic metres per hectare in the same decade as they attained 150 cubic metres per hectare. Since the age interval used for the volume tables in this analysis was a decade, the minimum harvestable ages used in this sensitivity analysis were not significantly different from those used in the base case.

If minimum harvestable ages were set at the age where the average rate of growth is a maximum (culmination of mean annual increment*), medium-term timber supply would be 10% lower than in the base case. In the long term, timber supply would only be 5000 cubic metres per year higher than the base case. Changing the minimum harvestable ages to the culmination ages* increases the harvestable ages for most analysis units and decreases the harvestable ages for some. As well, regenerating stands, which are critical to timber supply during the transition of harvesting from old-growth to second-growth, must age an additional three to four decades on average before they are considered harvestable. As a result, when existing older stands are unavailable for harvest during the transition period, there are not as many regenerating stands old enough to be harvested under this management regime as there are in the base case. Thus, the harvesting of existing timber must occur at a slower rate to avoid serious timber supply disruptions in the future.

In this analysis, minimum harvestable ages are not viewed as decisions made to meet forest management objectives, but rather as approximations of the timing of merchantability. This analysis highlights that timber supply is sensitive to uncertainty about this timing. Whether minimum harvestable ages used in the base case are appropriate, optimistic, or pessimistic is largely a matter of opinion. These issues are discussed here because of all variables important to timber supply, minimum harvestable ages are perhaps the most uncertain, at least in areas where most second growth will not be harvested for many years. Many other variables are based on sampling data and experience, or management decisions. Minimum harvestable age, however, will depend on technology and markets well into the future.

5.11 Alternative harvest queue rules

In the base case, the highest priority for harvest is given to stands that are oldest relative to their minimum harvestable age. This 'relative oldest first' rule is applied only after other requirements and priorities (e.g., forest cover requirements) are taken into account. This rule reflects the practice of favouring older stands, but not necessarily the oldest, for harvest when all other considerations have been met.

Mean annual increment (MAI)
Stand volume divided by stand age. The age at which average stand growth, or MAI, assumes its maximum is called the culmination age. Harvesting all stands at this age results in a maximum average harvest over the long term.

Culmination age
The age at which a timber stand reaches its highest average growth rate, or mean annual increment (MAI). MAI is calculated as stand volume divided by stand age. Culmination age is the optimal biological rotation age to maximize volume production from a growing site.

Besides the relative oldest first rule, the Forest Service Simulator (FSSIM) model permits use of absolute oldest first, absolute youngest first or random scheduling rules. These other rules may better reflect practices in some instances, given unforeseeable operational constraints that may affect when stands are chosen for harvest. Figure 26 shows how potential harvest levels are affected by changing the way stands are prioritized for harvest.

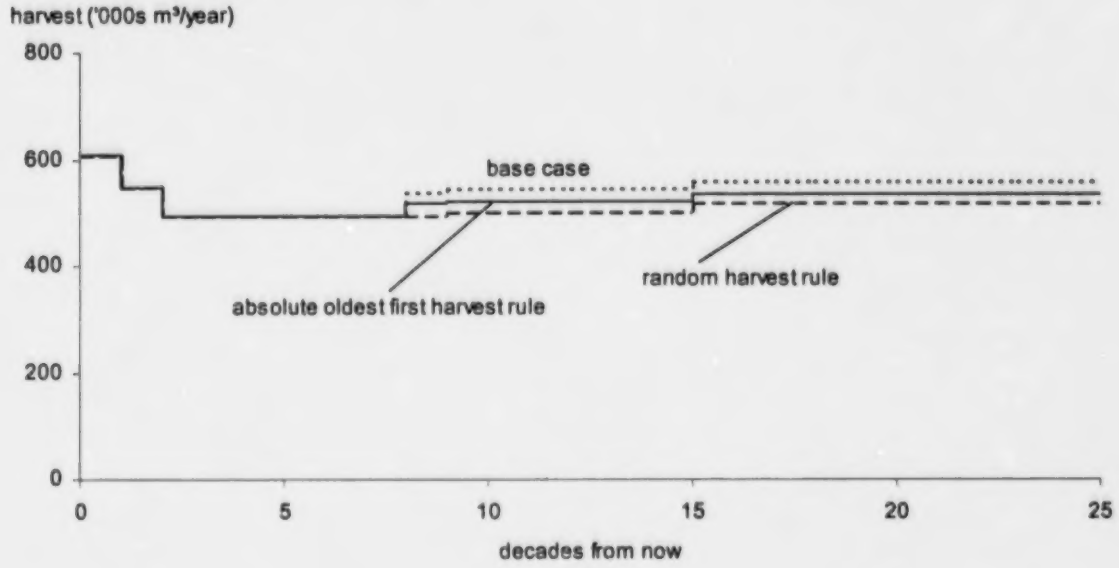

Figure 26. Alternative harvest queue rules — Arrow TSA, 2000.

The 'random harvest scheduling' rule chooses stands that are older than the minimum harvestable age in a random order for harvesting, whereas the 'absolute oldest first' harvest rule schedules for harvest all stands above the minimum harvestable age simply by the stand age. If stands were ordered for harvest using the random harvest scheduling rule instead of the 'relative oldest first' rule, the projected long-term harvest level could be about 7% less than the base case level. If the absolute oldest first harvest rule was more reflective of the way stands were chosen for harvesting then the long-term harvest level would be about 4% less than that obtained in the base case.

5.12 Uncertainty in the application of landscape-level biodiversity requirements

As described in Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis", prescriptions for maintaining biodiversity at both the stand level and the landscape level were modelled in the base case. Stand-level biodiversity was addressed in this analysis by removing portions of each stand from the timber harvesting land base. Uncertainty about stand-level biodiversity can be assessed through sensitivity analysis that examine the timber supply impacts of land base reductions. Landscape-level biodiversity, however, was modelled in this analysis through the use of forest cover requirements applied to biogeoclimatic variants within each landscape unit. There is uncertainty about how the recommendations in the *Biodiversity Guidebook* should be interpreted and the land base to which they are applied. The following sensitivity analyses provide an indication of the risk associated with uncertainty about landscape–level biodiversity.

Management for landscape-level biodiversity in the Arrow TSA includes provision for the maintenance of young and mature forest as well as old-growth forest. The base case included the requirements for mature forest and for old forest but the requirement for young forest was not modelled. A sensitivity analysis which included the requirement for young forest showed no change in the timber supply obtained in the base case. Another analysis which removed the requirement for mature forest showed that timber supply in the medium term could be increased by about 5%.

There is a concern that attempting to meet the mature and old-forest requirements from the areas outside of the timber harvesting land base may not result in adequate representation of all the different kinds of forests (site series) which comprise a biogeoclimatic variant. Figure 27 illustrates the effect of forcing some of the forest cover requirement to be met from the operable land base thereby increasing the probability that the full variety of old forest will be represented across the landscape rather than being concentrated in inoperable areas. In this sensitivity analysis the operable forest was required to provide an amount of forest cover equal to its proportion of the landscape unit. This change in the application of landscape-level forest cover requirements results in a reduction of timber supply in the medium- and long-term of 5000 cubic metres per year.

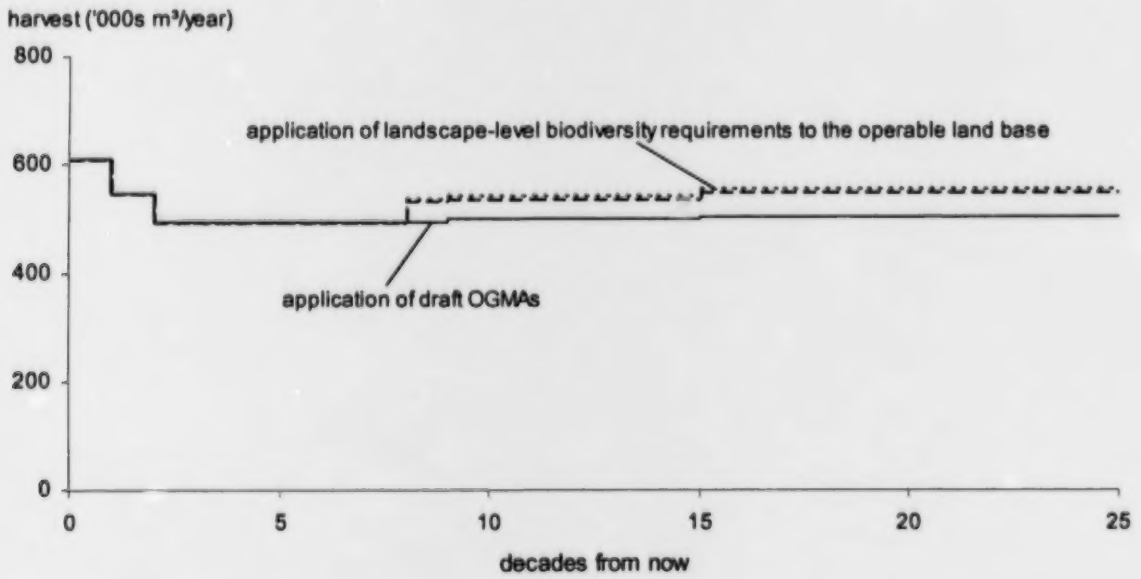

Figure 27. Harvest forecasts if landscape-level biodiversity assumptions are changed — Arrow TSA, 2000.

In the base case it is possible for forest cover requirements within a landscape unit to be met by several small and geographically separated pieces of land that meet the specified forest cover criteria. However, stand age is not the only criterion for identifying old-growth habitat. The *Landscape Unit Planning Guide* recommends the establishment of large, contiguous areas of old forest in order to provide old-growth interior forest conditions. The Arrow Forest District has identified 51 297 hectares of draft old-growth management areas (OGMAs) in the TSA. Of this area, 19 938 hectares were considered part of the timber harvesting land base. If approved, these OGMAs, together with the other forested areas excluded from the timber harvesting land base, are expected to provide the old-growth forest necessary for the preservation of biological diversity. Figure 27 shows that when the draft OGMAs, which comprise approximately 10% of the timber harvesting land base, were reserved from harvest the long-term timber supply was reduced by about 9%.

6 Alternative Forest Management and Land Use Assumptions

The base case represents the timber supply available from the Arrow TSA under a certain set of land use decisions, forest management practices and assumptions about future growth of the forest. This section presents the timber supply implications from alternative sets of decisions about land use, forest management practices, and future forest growth. Table 7 shows the differences from the base case for each alternative.

Table 7. Alternative scenarios for timber supply in the Arrow TSA

Category	Base case	Alternative 1	Alternative 2	Alternative 3
Slocan CORE sector review area	Keep in timber harvesting land base	Same as base case	Same as base case but limit its harvest to 50 000 m^3 per year	Remove from timber harvesting land base
Wildlife tree patches	Reduce timber harvesting land base by 3.5%	Reduce timber harvesting land base by 1.7%	Same as base case	Same as base case
Area reduction for S4 streams	Stream classification based on watershed atlas	Same as base case	Same as base case	Reduce timber harvesting land base by an additional 2%
Landscape-level biodiversity	Apply guidebook requirement for mature plus old forest	Remove requirement for mature plus old forest	Old-growth management areas replace old-growth requirements in base case	Same as alternative 2
Results from OGSI study	Not in base case	Apply results for every species	Apply results for pine and spruce only	Same as base case
Old-forest requirement for caribou habitat	40% > 140 years 10% > 250 years 25% < 2 metres	40% > 100 years 10% > 250 years 25% < 2 metres	Same as base case	40% > 140 years 10% > 250 years 25% < 3 metres
Visually sensitive areas	Retention – 5% > 7 m Partial retention – 15% > 7 m Modification – 25% > 7 m	Retention – 10% > 7 metres Partial retention – 20% > 7 m Modification – 30% > 7 metres	Same constraints as in base case but applied at the polygon level rather than at the landscape-unit level	Same as alternative 2
Forest cover for ungulate winter range	40% > 100 years 25% < 2 metres tall	30% > 100 years 25% < 2 metres tall	Same as base case	40% > 120 years 25% < 3 metres tall
Forest cover for domestic and community watersheds	Class 1 15% < 6 m Class 2 & community 20% < 6 m Class 3 25% < 6 m	Class 1, 2, 3 & community watersheds 35% < 6 m	Same as base case	Class 1 15% < 9 m Class 2 & community 20% < 9 m Class 3 25% < 9 m
Forest cover for regionally significant fish streams	25% < 6 metres	25% < 2 metres	Same as base case	25% < 9 metres
Root rot	OAF 2 of 5% for all regenerated stands	Same as base case	OAF 2 of 10% for all regenerated stands	Same as base case
Harvest rule	Relative oldest first	Same as base case	Same as base case	Random
Minimum harvestable ages	Age when stands attain both 150 m^3/ha and 25 cm dbh	Same as base case	Same as base case	Age when stand growth is within 95% of culmination mean annual increment
Integrated resource management	25% < 2 metres 40% > 70 years	25% < 2 metres	Same as base case	25% < 3 metres 40% > 70 years

6 Alternative Forest Management and Land Use Assumptions

Figure 28 shows one possible timber supply projection for each of these alternatives as well as the base case projection. Alternative 1 shows that it is possible to maintain the current harvest level for nine decades before rising to a long-term level of 687 000 cubic metres per year. If the Arrow TSA was managed under the practices and assumptions of alternative 3, timber supply would be reduced to 346 280 cubic metres per year, a reduction of 43% from the base case.

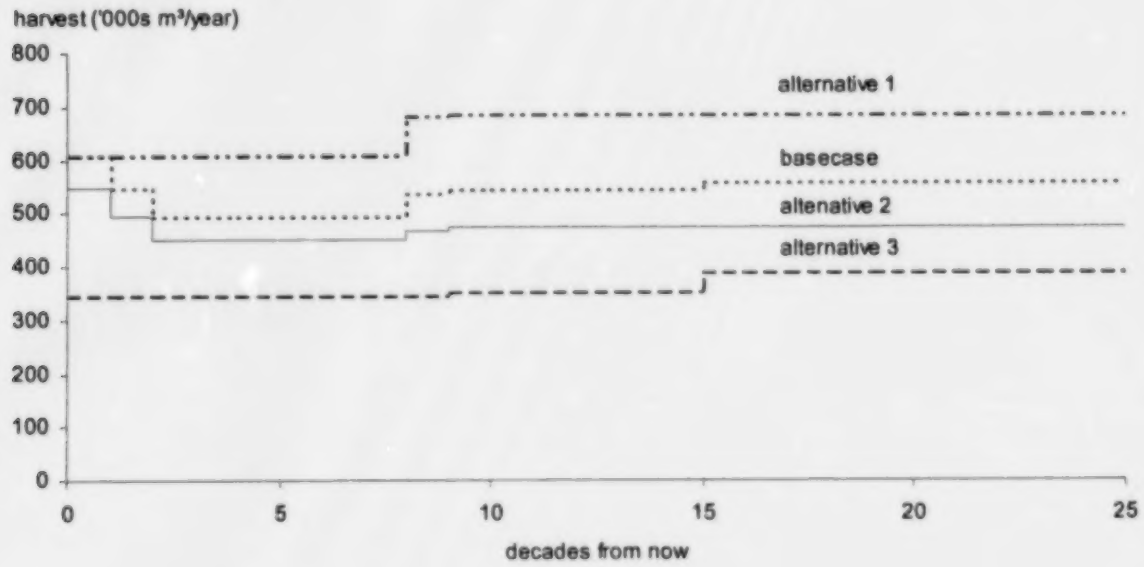

Figure 28. Harvest forecasts based on alternative forest management assumptions — Arrow TSA, 2000.

The increased timber supply obtained under alternative 1 as compared to the base case is due mainly to the change in forest cover requirements for visually sensitive areas and the application of the results from the OGSI study. The reduced timber supply shown under alternative 3 is mostly due to the fact that the timber harvesting land base is about 26% lower than that in the base case.

7 Summary and Conclusions of the Timber Supply Analysis

The results of this timber supply analysis suggest that the current allowable harvest level in the Arrow TSA of 609 300 cubic metres per year can be maintained for up to ten years without either requiring substantial and rapid future harvest level reductions, or creating severe future timber supply disruptions. Using current inventory and timber growth information and assuming continuation of current forest management practices, harvests could be maintained at the current level for ten years, if followed by a decline of 10% per decade for the following two decades. The harvest can then be increased in decade nine and again in decade sixteen to a long-term harvest level of 557 000 cubic metres per year.

The base case results reflect current knowledge and information on forest inventory, growth and management. However, uncertainty exists about several factors important in defining timber supply. A series of sensitivity analyses showed that these uncertainties affect timber supply to varying degrees.

Short-term timber supply is sensitive to changes which influence the amount of timber available from existing unmanaged stands because the harvest forecast relies on harvests from these stands for the next 90 years. The largest potential negative effects on base case projected harvest levels over the short term (next 20 years) result from reductions in estimates of timber volume in existing stands and the size of the timber harvesting land base. An audit conducted in 1997 showed that the inventory estimates of volume for mature stands (over 60 years old) on the physically and economically operable land base are not statistically different from volumes derived using ground measurements. Overall, the audit therefore suggests that the inventory reasonably portrays the standing timber volume in existing stands at the TSA level. The size of the timber harvesting land base will be affected by decisions regarding the level of harvesting activities in the Slocan valley, which makes up 14% of the timber harvesting land base. In the base case, the harvest from the Slocan valley is approximately 80 000 cubic metres per year in the short term, and 60 000 cubic metres per year in the long term. If the harvest from the Slocan valley is limited to 50 000 cubic metres per year, the current harvest level from the Arrow TSA would have to be decreased by about 5% to keep medium-term harvest levels similar to those in the base case. If medium-term harvest levels are allowed to fall below the base case levels, then the current harvest does not have to be decreased. Further limitations on the contribution from the Slocan valley result in larger decreases to the initial harvest level obtainable from the Arrow TSA.

Medium-term (21 to 80 years from now) timber supply is affected by estimates of: time taken to achieve green-up conditions, incidence of root rot in regenerated stands, forest cover requirements for management of visual quality, as well as the factors affecting short-term timber supply mentioned above. Reduction in the time to green-up had little effect on timber supply, whereas an increase in the time substantially reduce both medium- and long-term timber supply. The estimates of time taken to achieve green-up conditions for this TSA were derived by examining height growth data for regenerating stands in the Nelson Forest Region. While no data are available to estimate the extent of root rot in future stands, the analysis shows that root rot can have a significant impact on timber supply if the merchantable volume of those stands is reduced by as much as 20%. Visual quality guidelines apply to 36% of the timber harvesting land base and can affect both the medium- and long-term timber supply. If the visual absorption capacities in the visually sensitive areas were lower than modelled, then medium- and long-term timber supply would be considerably lower than shown for the base case.

Long-term timber supply is affected by uncertainties in: the application of landscape-level biodiversity, estimates of regenerated stand yields, estimates of site productivity for old-growth stands, the availability of seeds from seed orchards, as well as all of the factors with large potential effects on medium-term timber supply mentioned above.

In addition to the base case, which evaluates current land use decisions and forest management practices, three alternative sets of forest management assumptions and land use decisions were evaluated. The alternatives investigated various levels of management for non-timber values, and changes to timber management strategies. Results showed that timber supply over all time frames could be altered significantly by changes in management emphasis and objectives.

7 Summary and Conclusions of the Timber Supply Analysis

In conclusion, this analysis indicated that based on current inventory and growth and yield information, and the current management regime, timber harvests in the Arrow TSA can be maintained at the current level for the next ten years. The analysis indicates that several factors related to the current forest inventory and management regime could affect timber supply.

The two factors most likely to affect the timber supply projected in the base case are the uncertainty associated with harvesting in the Slocan valley, and the likelihood that site index estimates for old-growth stands under-estimate actual productivity for regenerating stands. For other factors, there is no conclusive evidence to suggest that the information used in this analysis contains significant inaccuracies.

8 Socio-Economic Analysis

The impact of timber supply adjustments on local communities and the provincial economy is an important consideration in the Timber Supply Review. The socio-economic analysis compares the level of employment and economic activity currently supported by timber harvested from the Arrow TSA to the level of activity that could be expected given the timber supply projected in the base case forecast.

The socio-economic analysis uses the base case harvest forecast as an indication of timber supply levels and does not examine alternative management scenarios.

The socio-economic analysis includes:

- a profile of the current socio-economic setting;
- a description of the Arrow TSA forest industry; and,
- an analysis of the socio-economic implications of the base case harvest forecast.

8.1 Current socio-economic setting

8.1.1 Overview

The socio-economic analysis focuses on the timber supply from the Arrow TSA; however, the TSA is part of the larger Arrow Forest District. The forest district includes portions of Tree Farm Licences (TFLs) 3 and 23, and a number of woodlot licences. Since there are communities located throughout the forest district and employment is not easily separated between the TSA, TFLs and woodlots, this section profiles the forest district, instead of the TSA. Section 8.3 describes the socio-economic impacts that result from changes to the Arrow TSA timber supply, and how those changes could affect communities within the larger forest district and province.

8.1.2 Current population and demographic trends

The Arrow TSA, one of seven TSAs in the Nelson Forest Region, has a population of about 46,000 people (1996 Census). The major communities are Castlegar and Trail, with a combined population of nearly 15,000. Other communities include Rossland, Fruitvale, Montrose, Warfield and Nakusp. Table 8 indicates that, from 1991 to 1996, the population of the TSA increased by more than 8% or about 1.5% annually. By 2001, the population of the area is projected to be an estimated 47,625, an increase of about 4% from 1996.

Table 8. Population statistics, Arrow Forest District, 1991–2001

Communities	Population 1991 census	Population 1996 census	Population 2001 estimate[a]	Per cent change 1996–2001
Castlegar	6,579	7,027	7,556	7.5
Trail	7,921	7,696	7,869	2.2
Rossland	3,559	3,802	3,888	2.3
Fruitvale/Montrose/Warfield	5,073	5,042	5,156	2.3
Nakusp	1,661	1,736	1,891	8.9
Other communities	17,452	20,452	21,265	4.0
Arrow TSA	**42,245**	**45,755**	**47,625**	**4.1**

Source: 1991 and 1996 Census of Canada.

(a) Estimates are by BCSTATS, based on local health area population projections.

8.1.3 Economic profile

From 1991 to 1996, the experienced labour force in the Arrow Forest District increased by 8.7% to 22,105. In comparison, the experienced labour force for the province increased by almost 14% over the same period. The unemployment rate in the Arrow Forest District was 11.8% in 1996, compared with 13.2% in 1991. As Figure 29 illustrates, the major employment sectors in the Arrow Forest District are the public sector (education, health, and federal, provincial and local public services), forestry, other primary industries (mainly mining) and tourism. Figures from the 1996 census indicate that total employment (direct, indirect and induced) in the forest sector accounted for about 19% of employment in the forest district.

Tourism, which includes portions of several service sectors such as accommodation services, retail trade and transportation, has demonstrated significant growth and investment in recent years. Almost 2,500 persons are employed in the Arrow Forest District's tourism sector, which caters to both tourist and business travellers. Approximately 300 businesses in the Arrow Forest District service visitors' needs, including outdoor recreation facilities, tours and attractions, retail and service businesses, food and beverage facilities, and accommodations.

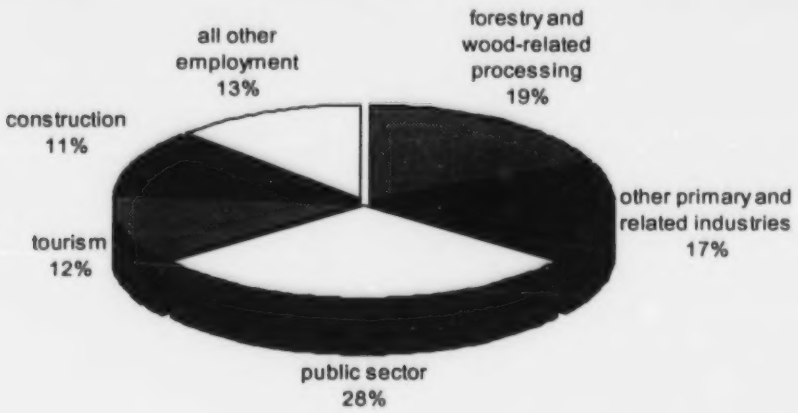

Figure 29. Estimates of total employment by sector, Arrow Forest District, 1996.
Source: Ministry of Finance and Corporate Relations. *The 1996 Forest District Tables.* April, 1999.

Income, whether business or personal, is another indicator of a sector's contribution to the economy. Jobs in sectors with high income levels tend to support more employment per job than those in sectors with lower income levels. Statistics Canada labour force data, comparing average weekly earnings in different sectors of the economy, indicate that the forest sector is one of the highest paying sectors. Therefore, it is a major contributor to the local and provincial economies. Mining is the only sector that has consistently paid higher wages than forestry. In 1998, the average weekly earnings (before income taxes) for the forest sector were approximately $915, compared with $1,116 for the mining sector. Other sectors' average weekly earnings were $723 for the construction industry; $254 for the accommodation, food and beverage services industries; and $779 for the public sector.

Employment multipliers reflect the income effect: the greater the multiplier, the greater the impact that each job in this sector has on the economy. For example, estimates by the Ministry of Finance and Corporate Relations indicate that for every 100 full-time direct forestry jobs in the Arrow Forest District, another 29-93 indirect and induced jobs* are supported, depending on the forestry activity (harvesting or timber processing). In comparison, for every 100 full-time direct jobs in the tourism sector, an estimated additional seven to 18 indirect and induced jobs are supported.

Indirect and induced jobs
Indirect jobs are supported by direct business purchases of goods and services. Induced jobs are supported by employee purchases of goods and services; for example, at retail outlets.

The differences are due to greater spending patterns by both forest sector businesses and their employees.

Table 9 compares estimated employment, average weekly earnings and employment multipliers for selected sectors of the Arrow Forest District's economy.

Table 9. Average weekly earnings and employment multipliers, Arrow Forest District

Industry sector	1998 average weekly earnings ($)	Employment multiplier[a]
Forestry and related	915	1.29-1.93
Mining and related	1,116	1.49-1.54
Construction	723	1.35-1.51
Tourism	254	1.07-1.18
Public sector	779	1.14-1.31

Sources: Statistics Canada. 1998. Survey of Employment, Payroll and Hours. Weekly earnings are before income taxes.

Ministry of Finance and Corporate Relations. 1999. The 1996 Forest District Tables. Refers to 1996 Census of Canada data.

(a) Includes direct, indirect and induced jobs.

8.2 Arrow TSA forest industry

8.2.1 Current allowable annual cut

The current AAC for the Arrow TSA, which was set in 1995, is 619 000 cubic metres and includes 9700 cubic metres per year for woodlot licences. Forest licences account for about 80% of the apportioned volume in the TSA. The Ministry of Forests Small Business Forest Enterprise Program (SBFEP) accounts for about 18% of the apportioned volume. The remaining volume, less than 3%, is apportioned to timber sale licences (TSLs), woodlot licences and the Forest Service Reserve. Table 10 indicates the current apportioned AAC by type of licence.

Table 10. Allowable annual cut apportionment, Arrow TSA, 1996

Type of licence	Volume (m^3)	Per cent (%)
Forest licences, replaceable	489 758	79.1
Timber sale licence (TSL) > 10 000 m^3, replaceable	0	0.0
Timber sale licence (TSL) < 10 000 m^3, replaceable	3 809	0.6
Small Business Forest Enterprise Program (SBFEP)	109 527	17.7
Forest Service Reserve	6 206	1.0
Woodlot licences	9 700	1.6
Total	**619 000**	**100.0**

Source: Ministry of Forests, Resource Tenures and Engineering Branch. 1996.

8.2.2 Arrow TSA harvest history

Actual harvest levels are important indicators of forestry activity in the TSA. While the AAC is the average maximum allowable annual harvest level, the actual volume of timber harvested in a particular year determines the level of economic activity. Differences in annual harvest levels are due to provisions for cut control,[1] which allow licensees to vary their harvest levels based on operating and market conditions. If the annual harvest level is consistently less than the AAC, then economic activity is less than the TSA's full potential. Table 11 summarizes the volume of timber harvested in the Arrow TSA from 1994 to 1998.

In addition to timber harvested from the TSA, the average annual harvest is 37 035 cubic metres from private lands and 7466 cubic metres from woodlots. These volumes are not included in this socio-economic analysis.

Table 11. Volume billed, by type of licence, Arrow TSA, 1994–1998

Type of licence	1994 (m³)	1995 (m³)	1996 (m³)	1997 (m³)	1998 (m³)	Average 1994–1998 (m³)
Forest licence	431 967	456 444	447 427	341 207	398 058	415 021
SBFEP	51 794	46 494	105 617	68 802	125 147	79 571
Timber sale licence (TSL)	1 148	7 700	5 501	0	0	2 870
Others[a]	6 791	5 148	40 042	60 896	57 617	34 099
Total	**491 700**	**515 786**	**598 587**	**470 905**	**580 822**	**531 561**
Allowable annual cut	**619 000**	**619 000**	**619 000**	**619 000**	**619 000**	

Source: Ministry of Forests, Harvest Database.

(a) Others include cutting permits for right-of-way clearings, roads, trespasses and other miscellaneous harvests.

8.2.3 Arrow TSA major licensees and processing facilities

The following section describes briefly the Arrow TSA's major licensees, other smaller licensees and processing facilities. The employment figures reflect volumes harvested from the Arrow TSA only.

(1) Cut control permits licensees to vary the volume between the annual harvest and the AAC by +/– 50% per year and by +/– 10% over a 5-year period. This variability gives licensees the flexibility to adapt to changing conditions, including changing markets.

Atco Lumber Ltd. (Atco)

Atco Lumber Ltd. (Atco) has a replaceable forest licence to harvest 167 438 cubic metres per year, unchanged from the level established before 1996. Almost all the harvest from this licence is processed at the company's lumber mills and veneer mill in the Arrow TSA. The remaining volume is processed at other facilities within the TSA.

Table 12 shows that, based on 1996-1998 data, Atco's average annual harvest from this licence supported an estimated 187-199 person-years of employment in harvesting, silviculture, timber processing and related activities. Almost all the workers associated with the harvesting and processing of the timber from this licence reside in the Arrow TSA.

Table 12. Atco's annual average harvests and estimated employment, 1996–1998

Allowable annual cut	167 438 cubic metres
Average annual harvest (1996–1998)	181 434 cubic metres
1998 harvest	192 068 cubic metres
Estimated employment[a] (1996–1998)	Person-years
Harvesting and administration	53-54
Log transport	15
Road construction and maintenance	5
Silviculture	8-12
Timber processing	106-113
Total	**187–199**

Source: Ministry of Forests, Harvest Database.

(a) Based on 1996–1998 average annual harvest of 181 434 cubic metres. Estimates of employment are derived from information supplied by the licensee.

Bell Pole Co. Ltd. (Bell)

Bell Pole Co. Ltd. (Bell) has a replaceable forest licence to harvest 13 218 cubic metres per year, up 244 cubic metres from the previous Timber Supply Review. About 30% of the harvest from the licence is processed at plants within the Arrow TSA. Table 13 indicates that, based on 1996-1998 data, Bell's average annual harvest from this licence supported an estimated 12-20 person-years of employment in harvesting, silviculture, timber processing and related activities. Approximately 50% of the workers associated with the harvesting and processing of the timber from this licence reside within the Arrow TSA.

Table 13. Bell Pole's average annual harvests and estimated employment, 1996-1998

Allowable annual cut	13 218 cubic metres
Average annual harvest (1996–1998)	10 106 cubic metres
1998 harvest	1 892 cubic metres
Estimated employment[a] (1996–1998)	Person-years
Harvesting and administration	3-8
Log transport	1-2
Road construction and maintenance	< 1
Silviculture	1
Timber processing	6-8
Total	**12-20**

Source: Ministry of Forests, Harvest Database.

(a) Based on 1996-1998 average annual harvest of 10 106 cubic metres. Estimates of employment are derived from information supplied by the licensee and include employment associated with TSA timber that is processed outside the TSA.

Kalesnikoff Lumber Co. Ltd. (Kalesnikoff)

Kalesnikoff Lumber Co. Ltd. (Kalesnikoff) has a replaceable forest licence to harvest 38 322 cubic metres per year, unchanged from the previous Timber Supply Review. About 90% of the harvest from this licence is processed within the Arrow TSA at the company's lumber mill in Thrums. Table 14 shows that, based on 1996-1998 data, Kalesnikoff's average annual harvest supported an estimated 60-82 person-years of employment in harvesting, silviculture, timber processing and related activities. Approximately 95% of the workers associated with harvesting and processing of the timber from this licence live in the Arrow TSA.

Table 14. Kalesnikoff's average annual harvests and estimated employment, 1996-1998

Allowable annual cut	38 322 cubic metres
Average annual harvest (1996-1998)	36 227 cubic metres
1998 harvest	32 011 cubic metres
Estimated employment[a] (1996-1998)	Person-years
Harvesting and administration	15-18
Log transport	5-6
Road construction and maintenance	2-3
Silviculture	1
Timber processing	37-54
Total	**60–82**

Source: Ministry of Forests, Harvest Database.

(a) Based on 1996–1998 average annual harvest of 36 227 cubic metres. Estimates of employment are derived from information supplied by the licensee and include employment associated with TSA timber that is processed outside the TSA.

Riverside Forest Products Ltd. (Riverside)

Riverside Forest Products Ltd. (Riverside) has a replaceable forest licence to harvest 52 552 cubic metres per year, unchanged from the previous Timber Supply Review. Almost the entire volume of the harvest from this licence is processed outside the Arrow TSA at the company's veneer and lumber mills in the Kamloops Forest Region. Table 15 shows that, based on 1996-1998 data, Riverside's average annual harvest from this licence supported an estimated 32-41 person-years of employment in harvesting, silviculture, timber processing and related activities. Almost all the workers associated with harvesting and processing of the timber from this licence live outside the Arrow TSA.

Table 15. Riverside's average annual harvests and estimated employment, 1996–1998

Allowable annual cut	52 552 cubic metres
Average annual harvest (1996-1998)	53 837 cubic metres
1998 harvest	53 012 cubic metres
Estimated employment[a] (1996–1998)	Person-years
Harvesting and administration	5-8
Log transport	3-4
Road construction and maintenance	1
Silviculture	2-3
Timber processing	21-25
Total	**32-41**

Source: Ministry of Forests, Harvest Database.

(a) Based on 1996–1998 average annual harvest of 53 837 cubic metres. Estimates of employment are derived from information supplied by the licensee and include employment associated with TSA timber that is processed outside the TSA.

Slocan Forest Products Ltd. (Slocan)

Slocan Forest Products Ltd. (Slocan) has a replaceable forest licence to harvest 218 472 cubic metres per year, unchanged from the previous Timber Supply Review. More than 90% of the harvested volume from this licence is processed within the Arrow TSA at the company's lumber mill in Slocan. Table 16 shows that, based on 1996-1998 data, Slocan's average annual harvest from this licence supported an estimated 156-213 person-years of employment in harvesting, silviculture, timber processing and related activities. More than 90% of the workers associated with harvesting and processing of the timber from this licence live within the Arrow TSA. Slocan also has TFL 3, which is beside the Arrow TSA. TFL 3 has an AAC of 74 600 cubic metres (not including a SBFEP apportionment of 5400 cubic metres per year). The volume from this TFL is not included in this analysis.

Table 16. Slocan's average annual harvests and estimated employment, 1996–1998

Allowable annual cut	218 472 cubic metres
Average annual harvest (1996-1998)	113 734 cubic metres
1998 harvest	118 410 cubic metres
Estimated employment[a] (1996-1998)	Person-years
Harvesting and administration	53-81
Log transport	7-12
Road construction and maintenance	26-38
Silviculture	3
Timber processing	67-79
Total	**156–213**

Source: Ministry of Forests, Harvest Database.

(a) Based on 1996–1998 average annual harvest of 113 734 cubic metres. Estimates of employment are derived from information supplied by the licensee and include employment associated with TSA timber that is processed outside the TSA.

Pope and Talbot Ltd. (Pope and Talbot)

Pope and Talbot Ltd. (Pope and Talbot) has a timber sale licence (TSL) to harvest 3538 cubic metres per year. Because the volume in the TSL is relatively small when compared with the company's other licence in the area (TFL 23), estimates of employment and income generated by the volume in the company's TSL are based on industry averages for the TSA. Pope and Talbot's TFL 23 has an AAC of nearly 600 000 cubic metres (not including about 80 000 cubic metres apportioned to the SBFEP). Most of TFL 23 is within the Arrow Forest District. The volume from this TFL is not included in this analysis.

Table 17. Pope and Talbot's average annual harvests and estimated employment, 1996-1998

Allowable annual cut	3 538 cubic metres
Average annual harvest (1996-1998)	1 834 cubic metres
1998 harvest	0 cubic metres
Estimated employment[a] (1996–1998)	Person-years
Harvesting and administration	< 1
Log transport	< 1
Road construction and maintenance	< 1
Silviculture	< 1
Timber processing	1
Total	**2**

Source: Ministry of Forests, Harvest Database.

(a) Based on 1996–1998 average annual harvest of 1834 cubic metres. Estimates of employment are based on information from other licensees in the TSA.

Small Business Forest Enterprise Program (SBFEP)

The harvest volume in the Arrow TSA's SBFEP is 109 527 cubic metres per year, or about 18% of the TSA's apportioned AAC. The volume in the SBFEP has been reduced from 113 336 cubic metres since the previous Timber Supply Review. Annual harvests in recent years have averaged nearly 100 000 cubic metres, or about 15% of the total harvest in the TSA. An estimated 80% of the timber harvested under the SBFEP is processed within the TSA. Table 18 shows that, using average annual data from licensees and operators in the TSA, the volume harvested under the SBFEP supported an estimated 124 person-years of employment in harvesting, silviculture, timber processing and related activities. Registrants who reside within the Arrow TSA harvested approximately 80% of the timber cut in the SBFEP.

Table 18. Small Business Forest Enterprise Program annual average harvests and estimated employment, 1996-1998

Allowable annual cut	109 527 cubic metres
Average annual harvest (1996-1998)	99 855 cubic metres
1998 harvest	125 147 cubic metres
Estimated employment[a] (1996-1998)	Person-years
Harvesting and administration	38
Log transport	9
Road construction and maintenance	11
Silviculture	4
Timber processing	62
Total	**124**

Source: Ministry of Forests, Harvest Database.

(a) Based on 1996–1998 annual average harvest of 99 855 cubic metres. Estimates of employment are derived from industry averages of licensees and operators in the TSA and include employment associated with TSA timber that is processed outside the TSA.

Arrow TSA timber supply and processing capacity

Approximately 80% of the timber harvested in the Arrow TSA is processed within the TSA; the remaining 20% is processed in other areas of the province. Table 19 lists the timber processing facilities including 10 lumber mills, one pulp mill and a few pole plants, shake and shingle mills and a veneer plant and their estimated annual capacities. The processing facilities in the TSA have an estimated annual processing capacity of more than 2.2 million cubic metres. From 1994 to 1998, harvests in the TSA averaged approximately 530 000 cubic metres per year. Additional timber supply for processing facilities in the TSA comes from nearby TSAs, TFLs and private sources.

Table 19. Timber processing facilities and estimated annual capacities, Arrow Forest District, 1998

Name	Type of mill	Location of mill	Estimated annual capacity ('000s m³)
Antler Creek Contracting Ltd.	Lumber	Edgewood	15
Atco Lumber Ltd.	Lumber	Fruitvale	20
Atco Lumber Ltd.	Veneer	Fruitvale	160
Atco Lumber Ltd.	Lumber	Park Siding	345
B J Carney & Co. Ltd.	Pole	Nakusp	25
Box Lake Lumber Prod Ltd.	Lumber	Nakusp	65
Columbia River Shake/Shingle Ltd.	Shake & Shingle	Nakusp	60
Crescent Valley Cedar Ltd.	Shake & Shingle	Crescent Valley	10
Herridge Trucking and Sawmilling Ltd.	Lumber	Nakusp	15
Jones Ties and Poles (1978) Ltd.	Lumber	Rossland	35
Kalesnikoff Lumber Co. Ltd.	Lumber	Thrums	145
Pacific Inland Pole & Piling Ltd.	Pole	Nakusp	15
Paterson Pole Ltd.	Pole	Rossland	35
Pope & Talbot Ltd.	Lumber	Castlegar	735
Porcupine Wood Products Ltd.	Lumber	Salmo	80
Saddle Mountain Cedar Products Ltd.	Shake & Shingle	Nakusp	2
Slocan Forest Products Ltd.	Lumber	Slocan	430
Total solid wood processing			2192
Celgar Pulp Ltd.	Pulp	Castlegar	860[a]

Source: B.C. Ministry of Forests. 1998. Major Primary Timber Processing Facilities in British Columbia.

(a) Unit of measurement for fibre supply to pulp mill is thousands of bone dry units (000 BDU).

8.2.4 Forest sector employment and employment coefficients

Harvesting and employment information is used to estimate employment co-efficients which will be used to project future employment levels in the forest sector. For this purpose, the forest sector has been divided into three sub-sectors:

- harvesting and other woodlands-related employment such as log transportation, log salvage, log scaling, and harvest planning and administration;
- silviculture employment such as planting, surveying, and other basic and intensive silviculture activities, such as spacing, fertilization and pruning*; and,
- primary timber processing employment, such as manufacturing activities at lumber mills, veneer and plywood mills, shake and shingle mills and pulp and paper mills.

Pruning
The manual removal of the lower branches of crop trees to a predetermined height to produce clear, knot-free wood.

Harvesting and silviculture employment

The harvesting employment component of the forest industry is the most closely tied to the AAC and includes both company and contract loggers. Almost all the harvesting workforce reside in the Arrow TSA. Harvesting activity in the Arrow TSA occurs throughout the year but mostly during the 10 months from May to February. Ground-based harvesting systems are the main type of harvesting methods used. In recent years, more volume of timber has been harvested by cable systems and other innovative means such as helicopter logging.

Silviculture employment is perhaps the least tied to the current level of harvest, given that silviculture activities continue for up to 10-15 years following harvesting. Basic silviculture consists of surveys, site preparation, planting, brushing, cone collecting and some spacing. Enhanced, or intensive, silviculture includes spacing, fertilization and pruning. In the TSA, licensees are responsible for basic silviculture on areas harvested under major licences. The provincial government is responsible for enhanced silviculture, basic silviculture on areas harvested under the SBFEP and silviculture on backlog not satisfactorily restocked (NSR) areas.

The 1994 *Arrow TSA Socio-Economic Analysis*, prepared for the previous Timber Supply Review, identified an average of 330 person-years of direct employment in harvesting and silviculture throughout the province, associated with annual harvest volumes of approximately 619 000 cubic metres. The survey completed for the current Timber Supply Review indicates that from 1996 to 1998, the average annual harvest of approximately 550 000 cubic metres supported an estimated 281 person-years of direct employment in harvesting and silviculture activities in the province.

Processing employment

Timber harvested from the Arrow TSA is processed mainly into lumber, veneer and wood chips. A small portion of the harvest is processed into other products such as shake and shingles, poles and posts at mills in the TSA and in neighbouring TSAs. Wood chips are shipped to the mill at Castlegar for further processing into pulp. Mills in the TSA also process timber that is harvested from other TSAs and private sources.

The 1994 *Arrow TSA Socio-Economic Analysis* estimated that the average annual timber harvest in the Arrow TSA of approximately 619 000 cubic metres supported an average of 304 person-years in timber processing employment. The survey completed for the current Timber Supply Review indicates that the average annual harvest for the TSA was approximately 550 000 cubic metres and supported an estimated 345 person-years of timber processing employment in the province.

Ministry of Forests employment

The Arrow TSA is administered by the Arrow Forest District office in Castlegar. About 63 people work in the forest district office. District staff oversee the management of forestry-related activities on Crown land in the TSA. Employment in the Ministry of Forests is not included in direct employment in the forest sector because it is more related to administration and enforcement of statutory requirements than to the timber harvest levels. Marginal changes in the timber supply would not normally affect this employment. Ministry employees are, nevertheless, an important component of the total employment in the TSA and are accounted for in the government service component of the public sector.

Employment coefficients

Table 20 summarizes the employment supported by the 1996 to 1998 harvests in the Arrow TSA and the corresponding employment coefficients. These coefficients have been calculated at a TSA and provincial level to highlight the importance of the forestry sector within the Arrow TSA and to identify the contribution that the Arrow TSA's forestry sector makes to the provincial economy. The two employment levels are defined as follows:

1) TSA employment and employment coefficients are comprised of residents of the Arrow TSA who are employed in the forest sector within the Arrow TSA and whose jobs depend on the Arrow TSA timber supply; and,
2) provincial employment and employment coefficients are comprised of all forestry sector employment in the province that relies on the Arrow TSA timber supply, including both residents of the Arrow TSA and those who live elsewhere.

Employment is divided into direct, indirect and induced components; the sum of the components is the total impact. The coefficients are expressed as the number of full-time jobs, or person-years, per 1000 cubic metres of timber harvested. Indirect and induced employment figures were derived using employment multipliers developed by the Ministry of Finance and Corporate Relations.

For more detailed information regarding employment coefficients, see Appendix B, "Socio-Economic Analysis Background Information."

Table 20. Forest sector employment and employment coefficients, Arrow TSA

Activity	Within TSA		Province	
	TSA employment (person-years)	TSA employment coefficient (person-years per '000s m³)	Province employment (person-years)	Province employment coefficient (person-years per '000s m³)
Harvesting	230	0.42	258	0.47
Silviculture	18	0.03	23	0.04
Timber processing	293	0.53	345	0.63
Total: direct employment	541	0.98	626	1.14
Indirect/Induced employment	303	0.55	820	1.49
Total	844	1.53	1,446	2.63

Notes:

1. Based on 1996–1998 average annual harvest of 550 105 cubic metres and related employment in the Arrow TSA. Employment estimates are reported in person-years (PY). Due to rounding, some totals may not equal the sum of their components.
2. Other employment coefficients may be found in other documents for the same or similar areas. A difference in ratios can occur for several reasons, such as using different sources of employment data and rounding of estimates, dividing employment by a different harvest level, using a different definition of full-time employment and changing the definition of forestry sub-sectors. However, the relative impacts associated with a timber supply change should be similar.

8.2.5 Forest sector employment income

In 1998, the average annual income of forestry employees was $45,550 for those working in logging and forestry services, $44,915 for those working in solid wood manufacturing, and $52,250 for those working in pulp and paper mills. For those engaged in indirect and induced employment (such as construction, business services, retail trade, etc.), the estimated average annual income in 1998 was $34,075. Based on 1996-1998 annual averages, the Arrow TSA's timber harvest supported approximately $28.9 million in direct employment income and an additional $27.9 million of indirect and induced employment income per year. Table 21 shows that the harvest supported an estimated total of $56.8 million in employment income, or approximately $103,000 per 1000 cubic metres harvested.

Table 21. Estimate of forest sector provincial employment income, Arrow TSA

Employment component	Estimated person-years of employment	Estimated annual income per worker	Total employment income (1998 $ millions)	Employment income ($ per '000s m³)
Direct employment				
Logging and forestry services	281	$45,550	$12.80	$23,268
Solid wood processing	270	$44,915	$12.13	$22,050
Pulp and paper processing	75	$52,250	$3.92	$7,126
Subtotal	626		$28.85	$52,444
Indirect/induced employment	820	$34,075	$27.94	$50,793
Total	1,446		$56.79	$103,237

Note: Based on 1996-1998 average annual harvest of 550 105 cubic metres and related employment in the Arrow TSA. Employment estimates are reported in person-years (PY). Due to rounding, figures for employment income per '000s m³ may not equal the quotient resulting from the division of total employment income by the 1996–1998 average harvest.

Source: Statistics Canada. 1998 data. *Survey of Employment, Payroll and Hours.*

8.2.6 Provincial government revenues

The provincial government receives taxes and revenues from the forest industry. The forest industry pays stumpage, royalties and rent to the provincial government for the right to harvest and use timber. The forest industry also pays operating taxes such as logging, corporate income, property, gasoline and sales taxes. As well, the provincial and federal governments receive revenues from forestry employees through income taxes.

From 1996 to 1998, the timber harvest in the Arrow TSA contributed approximately $9.76 million in stumpage and rent payments annually to the provincial government. Other taxes paid by the forest industry, such as logging, corporate income, property and sales taxes, contributed approximately $4.77 million annually. In addition, the provincial government received approximately $4.83 million annually in income taxes paid by forest sector employees. Table 22 summarizes the main sources of provincial revenues from the forest industry in the TSA. Altogether, the timber harvest in the Arrow TSA contributed an estimated $19.36 million annually to provincial government revenues.

Table 22. Estimate of average annual revenues, Arrow TSA

Provincial revenue sources	Estimated average annual revenues ($ millions)	Average annual revenue ($ per '000s m³)
Stumpage and related revenues[a]	$9.76	$17,750
Forest industry taxes[b]	$4.77	$8,664
Employment income taxes[c]	$4.83	$8,788
Total	**$19.36**	**$35,202**

Note: Based on 1996–1998 average annual harvest of 550 105 cubic metres and related employment in the Arrow TSA. Due to rounding, figures for average annual revenue per '000s m³ may not equal the quotient resulting from the division of estimated average annual revenues by the 1996–1998 average harvest.

(a) Ministry of Forests, Revenue Branch.

(b) Based on estimates by Price Waterhouse Coopers (1999), and includes taxes for logging, corporate income, corporate capital, sales, property and electricity.

(c) Estimated from Revenue Canada income tax rates and includes only the provincial share of income taxes paid.

8.3 Socio-economic implications of the base case harvest forecast

The base case harvest forecast for the Arrow TSA is lower than the current AAC of 619 000 cubic metres by 9700 cubic metres to account for the establishment of new woodlot licences since 1995. The base case harvest forecast for the first decade is 609 300 cubic metres per year; in decade two, 548 400 cubic metres per year; for decades three to eight, 493 500 cubic metres per year; for decades nine to 15, about 544 000 cubic metres per year. From decade 16 onwards, the base case harvest forecast is 557 000 cubic metres per year.

The socio-economic analysis focuses on harvest level changes in the short- to medium-term (10-30 years from now) and considers:

- the implications for both the Arrow TSA and the province of alternative harvest levels;
- possible impacts on the communities within the TSA;
- log supply requirements of timber processing facilities within the Arrow TSA; and,
- regional timber supply implications.

The socio-economic analysis considers average levels of forestry activity that the base case harvest forecast could support, assuming no change in the employment and income generated by the forestry sector in the provincial economy, and labour productivity in the industry. The analysis also assumes that the proportions of harvesting, silviculture and timber processing employment, per cubic metre, remain constant and that the types and portions of wood products manufactured from the current level of harvest remain the same.

Employment impacts associated with future harvest levels are calculated using employment coefficients (person-years of employment per 1000 cubic metres). This method of calculating employment coefficients assumes that employment levels in the future can be predicted using current conditions of employment and the volume of timber harvested or processed. While this method can be reasonably accurate for short-term forecasts (within the next three to five years), employment coefficients 20 years from now may be very different due to changes in forest products market conditions, timber processing technologies, etc. The analysis indicates the size of impacts on employment, employment income and provincial government revenues, within a constantly changing socio-economic environment.

8.3.1 Short-and long-term implications of alternative harvest levels

Employment and income impacts in the Arrow TSA

Using 1996-1998 annual averages, the base case harvest forecast of 609 300 cubic metres per year will support an estimated 935 person-years of total employment (direct, indirect and induced) in the TSA in decade one, 841 person-years of total employment in decade two; and 757 person-years of total employment in decades three to eight. Employment will tend to fluctuate around these levels as companies respond to market changes and adjust harvesting activities under cut control regulations.

Average annual employment income generated in the Arrow TSA is estimated to be $39.0 million in decade one, $35.1 million in decade two, and $31.6 million in decades three to eight.

Employment and employment income impacts in the province (including the Arrow TSA)

Provincial level employment and income impacts include all the activity supported by the Arrow TSA harvest, regardless of the location of processing facilities or the residences of workers. The base case harvest forecast of 609 300 cubic metres per year in decade one will support an estimated 1,602 person-years of total employment (direct, indirect and induced) in the province and generate an estimated $62.9 million per year in employment income. In decade two, the base case harvest forecast of 548 400 cubic metres per year will support an estimated 1,441 person-years of total employment and generate an estimated average annual employment income of $56.6 million. For decades three to eight, the base case harvest forecast of 493 500 cubic metres per year will support an estimated 1,297 person-years of total employment and generate an estimated average annual employment income $50.9 million.

Provincial government revenues

Provincial government revenues from the forest industry include stumpage, royalties and rent payments; other taxes such as logging, corporate income, sales, property and electricity taxes; and income taxes paid by workers whose livelihoods are derived from the industry by direct, indirect and induced employment. Under existing tax and stumpage regimes, the base case harvest forecast of 609 300 cubic metres per year in decade one would, if the entire volume were harvested and utilized, generate an estimated $26.7 million (1998 dollar value) annually in provincial government revenues. In decade two, provincial government revenues generated are estimated to be $24.1 million per year; for decades three to eight, $21.7 million per year.

The estimated changes to employment, employment income and provincial government revenues, in the TSA and in the province, are summarized in Table 23.

8.3.2 Community level impacts

The impacts of short- and long-term changes in timber supply will be much greater on an economy which depends on the local timber supply than on one which is more diversified. Compared with the economies of other TSAs, the economy of the Arrow TSA is relatively diversified, although still quite dependent on the forest sector. As discussed in Section 8.1.3, the tourism sector has grown significantly in recent years and has helped to diversify the local economy.

The base case harvest forecast for decade one is slightly less than the current AAC, to account for recently allocated woodlots, indicating a relatively stable timber supply to maintain the existing level of forestry activity in the Arrow TSA. The base case harvest forecast for the Arrow TSA in the long term, beginning in decade 16, is 557 000 cubic metres per year, about 10% less than the current AAC of 619 000 cubic metres.

8.3.3 Timber requirements of processing facilities in the Arrow TSA

From 1996 to 1998, harvests on Crown land in the Arrow TSA averaged approximately 550 100 cubic metres per year. Most of the timber from this harvest was processed within the TSA. Timber processing capacity in the Arrow TSA is estimated at more than 2.0 million cubic metres per year. Additional timber supplies for the TSA's processing facilities came from nearby TSAs, TFLs and private sources from within and outside the TSA.

8.3.4 Regional timber supply implications

The flow of timber across TSA boundaries means that communities in the Arrow TSA can be vulnerable to timber supply changes in other districts. Information from the previous timber supply review indicates that the timber supply in the south-east Kootenay region could decline by about 15% or almost 320 000 cubic metres within the next 20 years.[2] Since mills in the Arrow TSA depend on neighbouring management units and private sources for more than 50% of their timber supply, future reductions in neighbouring timber supply areas could affect the timber supply available to these mills. This outlook may change as each successive Timber Supply Review re-examines the timber supply in the region. The *Kootenay-Boundary Land Use Plan* may have further implications pertaining to timber supply increase or decreases for communities as the timber supply is adjusted to meet the objectives of the land use plan. How these processes may eventually impact the Arrow TSA will depend on the actual timber supply changes, the composition of the industry and timber flows at the time.

(2) These estimates are based on the most recent Timber Supply Review base case forecasts for Kootenay Lake TSA, Boundary TSA, TFL 23 and TFL 3. The combined timber supply volume for these management units is currently 2.1 million cubic metres and the harvest level is forecast to be 1.8 million cubic metres by the year 2017.

Table 23. Socio-economic impacts of implementing the base case harvest forecast, Arrow TSA, 1999

	At current AAC[a]	Base case harvest forecast		
		Decade 1	Decade 2	Decade 3-8
Harvesting activity		('000s m^3)		
Current timber supply	619.0	609.3	548.4	493.5
Harvest level (1996-1998 average)	550.1			
Difference from current AAC	+ 68.9	– 9.7	– 70.6	– 125.5
Arrow Timber Supply Area				
Employment		(person-years)		
Direct	609	599	539	485
Indirect / induced	341	336	302	272
Total	950	935	841	757
Range of employment gain or (loss)		(13 to 15)	(93 to 108)	(166 to 192)
Employment income		($ millions)		
Direct	28.1	27.6	24.8	22.4
Indirect / induced	11.6	11.4	10.3	9.3
Total	39.7	39.0	35.1	31.6
Range of income gain or (loss)		(0.6)	(4.0 to 4.5)	(7.1 to 8.0)
Province, including Arrow TSA[b]				
Employment		(person-years)		
Direct	704	693	624	562
Indirect / induced	923	908	817	736
Total	1,627	1,602	1,441	1,297
Range of employment gain or (loss)		(22 to 25)	(159 to 186)	(283 to 330)
Employment income		($ millions)		
Direct	32.5	31.9	28.8	25.9
Indirect / induced	31.4	30.9	27.9	25.1
Total	63.9	62.9	56.6	50.9
Range of income gain or (loss)		(0.9 to 1.0)	(6.4 to 7.3)	(11.4 to 13.0)
Provincial government revenues		($ millions)		
Stumpage and related payments	10.99	10.82	9.73	8.76
Forest industry taxes	5.36	5.28	4.75	4.28
Employment income taxes	10.80	10.62	9.57	8.61
Total	27.16	26.73	24.06	21.65
Gain or (reduction) in revenues		(0.40 to 0.43)	(2.92 to 3.10)	(5.19 to 5.50)

(a) Estimates for current employment differ from those in Tables 20 and 21. Current employment figures in this table are based on the existing AAC of 619 000 cubic metres per year, while the figures in Tables 20 and 21 are based on the 1996–1998 average annual harvest volume of 550 100 cubic metres in the Arrow TSA. Due to rounding, some totals may not equal the sum of their components.

(b) Estimates of TSA employment and income impacts are included as part of the estimates of provincial employment and income impacts.

8.4 Summary

Forestry and mining are the two major resource sectors in the Arrow TSA's economy. Major forest licence holders in the TSA include Atco Lumber Ltd., Bell Pole Co. Ltd., Kalesnikoff Lumber Co. Ltd., Riverside Forest Industries Ltd., and Slocan Forest Products Ltd. Together, they account for about 80% of the apportioned AAC in the TSA. The Ministry of Forests' Small Business Forest Enterprise Program (SBFEP) accounts for approximately another 18%. Primary timber processing facilities include 10 lumber mills and a few pole plants, shake and shingle plants and a veneer mill. Together, these facilities have an estimated annual processing capacity of more than 2.0 million cubic metres. There is also a pulp mill in Castlegar.

The base case harvest forecast for the Arrow TSA is 609 300 cubic metres per year in decade one; 548 400 cubic metres per year in decade two; and 493 500 cubic metres per year in decades three to eight. The long-term base case harvest forecast (beginning in decade 16) is 557 000 cubic metres per year, which is about 10% less than the current AAC of 619 000 cubic metres.

For decade one, the base case harvest forecast would support an estimated 1,602 person-years of total employment (direct, indirect and induced jobs) annually in the province. This employment generates an estimated $62.9 million per year in employment income and an estimated $26.7 million per year in provincial government revenues. For decade two, the base case harvest forecast is estimated to support 1,441 person-years of employment, generating $56.6 million of employment income and $24.1 million in provincial government revenues per year. For decades three to eight, the base case harvest forecast is estimated to support 1,297 person-years of employment, generating $50.9 million of employment income and $21.7 million in provincial government revenues per year.

In the coming years, new light industries may locate in the Arrow TSA and sectors such as transportation, tourism and other services may increase their relative contribution to the local economy, providing additional stability and diversification to the economy in the Arrow TSA.

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10 Glossary

Allowable annual cut (AAC) — The rate of timber harvest permitted each year from a specified area of land, usually expressed as cubic metres of wood per year.

Analysis unit — A grouping of types of forest - for example, by species, site productivity, silvicultural treatment, age, and or location, done to simplify analysis and generation of timber yield tables.

Base case forecast — The timber supply forecast which illustrates the effect of current forest management practices on the timber supply using the best available information, and which forms the reference point for sensitivity analysis.

Biodiversity (biological diversity) — The diversity of plants, animals and other living organisms in all their forms and levels of organization, and includes the diversity of genes, species and ecosystems, as well as the evolutionary and functional processes that link them.

Biogeoclimatic (BEC) variant — A subdivision of a biogeoclimatic zone. Variants reflect further differences in regional climate and are generally recognized for areas slightly drier, wetter, snowier, warmer or colder than other areas in the subzone.

Biogeoclimatic zones — A large geographic area with broadly homogeneous climate and similar dominant tree species.

Clearcut harvesting — A harvesting method whereby all trees that meet utilization standards are harvested. The harvested site is then regenerated to acceptable standards by appropriate means including planting and natural seeding.

Culmination age — The age at which a timber stand reaches its highest average growth rate, or mean annual increment (MAI). MAI is calculated as stand volume divided by stand age. Culmination age is the optimal biological rotation age to maximize volume production from a growing site.

Cutblock — A specific area, with defined boundaries, authorized for harvest.

Drainage — The surface and sub-surface water derived within a clearly defined catchment area, usually bounded by ridges or other similar topographic features, encompassing part, most, or all of a watershed. The term is sometimes used to describe an operating area or location.

Employment coefficient — The number of person-years of employment supported by every 1000 cubic metres of timber harvested; for example, a coefficient of 1.0 indicates that every 1000 cubic metres harvested supports one person-year, or 500 000 cubic metres supports 500 person-years.

Employment multiplier — An estimate of the total employment supported by each direct job, for example a multiplier of 2.0 means that one direct job supports one additional indirect and induced job.

Environmentally sensitive areas — Areas with significant non-timber values, fragile or unstable soils, or impediments to establishing a new tree crop, or areas where timber harvesting may cause avalanches.

Forest cover objectives	Specify desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives. General adjacency and green-up guidelines are also specified using forest cover objectives.
Forest cover requirements	Specify desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives. General adjacency and green-up guidelines are also specified using forest cover objectives.
Forest inventory	An assessment of British Columbia's timber resources. It includes computerized maps, a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, and a description of other forest values such as recreation and visual quality.
Forest Practices Code	Legislation, standards and guidebooks that govern forest practices and planning, with a focus on ensuring management for all forest values.
Free-growing	An established seedling of an acceptable commercial species that is free from growth-inhibiting brush, weed and excessive tree competition.
Green-up	The time needed after harvesting for a stand of trees to reach a desired condition (usually a specific height) — to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics — before harvesting is permitted in adjacent areas.
Growing stock	The volume estimate for all standing timber, at a particular time.
Harvest forecast	The flow of potential timber harvests over time. A harvest forecast is usually a measure of the maximum timber supply that can be realized over time for a specified land base and set of management practices. It is a result of forest planning models and is affected by the size and productivity of the land base, the current growing stock, and management objectives, constraints and assumptions.
Indirect and induced jobs	Indirect jobs are supported by direct business purchases of goods and services. Induced jobs are supported by employee purchases of goods and services; for example, at retail outlets.
Inoperable areas	Areas defined as unavailable for harvest for terrain-related or economic reasons. Characteristics used in defining inoperability include slope, topography (e.g., the presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality. Operability can change over time as a function of changing harvesting technology and economics.
Integrated resource management	The identification and consideration of all resource values, including social, economic and environmental needs, in resource planning and decision-making.

Juvenile spacing

A silvicultural treatment to reduce the number of trees in young stands, often carried out before the stems removed are large enough to be used or sold as a forest product. Prevents stagnation and improves growing conditions for the remaining crop trees so that at final harvest the end-product quality and value is increased.

Landscape-level biodiversity

The *Forest Practices Code Biodiversity Guidebook* provides objectives for maintaining biodiversity at both the landscape level and the stand level. At the landscape level, guidelines are provided for the maintenance of seral stage distribution, patch size distribution and landscape connectivity.

Landscape unit

A planning area based on topographic or geographic features, that is appropriately sized (up to 100 000 hectares), and designed for application of landscape-level biodiversity objectives.

Long-term harvest level

A harvest level that can be maintained indefinitely given a particular forest management regime (which defines the timber harvesting land base, and objectives and guidelines for non-timber values) and estimates of timber growth and yield.

Management assumptions

Approximations of management objectives, priorities, constraints and other conditions needed to represent forest management actions in a forest planning model. These include, for example, the criteria for determining the timber harvesting land base, the specification of minimum harvestable ages, utilization levels, integrated resource guidelines and silviculture and pest management programs.

Mean annual increment (MAI)

Stand volume divided by stand age. The age at which average stand growth, or MAI, assumes its maximum is called the culmination age. Harvesting all stands at this age results in a maximum average harvest over the long term.

Natural disturbance type (NDT)

An area that is characterized by a natural disturbance regime, such as wildfires, which affects the natural distribution of seral stages. For example areas with less stand-initiating disturbance have more older forests, and generally a greater abundance of species.

Not satisfactorily restocked (NSR) areas

An area not covered by a sufficient number of well spaced tree stems of desirable species. Stocking standards are set by the B.C. Forest Service. Areas harvested prior to 1987 and not yet sufficiently stocked according to standards are classified as backlog NSR. Areas harvested or otherwise disturbed since 1987 are classified as current NSR.

Operability

Classification of an area considered available for timber harvesting. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.

Partial retention VQO

Alterations may be visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity (see Visual quality objective).

Person-year(s)	One person working the equivalent of one full year, defined as at least 180 days of work. If someone works full-time for 90 days, he or she accounts for 0.5 person-years.
Protected area	A designation for areas of land and water set aside to protect natural heritage, cultural heritage or recreational values (may include national park, provincial park, or ecological reserve designations).
Pruning	The manual removal of the lower branches of crop trees to a predetermined height to produce clear, knot-free wood.
Regeneration delay	The period of time between harvesting and the date by which an area is occupied by a specified minimum number of acceptable well-spaced trees.
Retention VQO	Alterations are not easy to see. Up to 5% of the visible landscape can be altered by harvesting activity (see Visual quality objective).
Riparian area	Areas of land adjacent to wetlands or bodies of water such as swamps, streams, rivers or lakes.
Riparian habitat	The stream bank and flood plain area adjacent to streams or water bodies.
Scenic area	Any visually sensitive area or scenic landscape identified through a visual landscape inventory or planning process carried out or approved by a district manager.
Sensitivity analysis	A process that examines how uncertainty in data and management assumptions affect timber supply.
Site index	A measure of site productivity. The indices are reported as the average height, in metres, that the tallest trees in a stand are expected to achieve at 50 years (age is measured at 1.3 metres above the ground). Site index curves have been developed for British Columbia's major commercial tree species.
Stand-level biodiversity	A stand is a relatively localized and homogeneous land unit that can be managed using a single set of treatments. In stands, objectives for biodiversity are met by maintaining specified stand structure (wildlife trees or patches), vegetation species composition and coarse woody debris levels.
Stocking	The proportion of an area occupied by trees, measured by the degree to which the crowns of adjacent trees touch, and the number of trees per hectare.
Timber harvesting land base	Crown forest land within the timber supply area that is currently considered feasible and economical for timber harvesting.
Timber supply	The amount of timber that is forecast to be available for harvesting over a specified time period, under a particular management regime.
Timber supply area (TSA)	An integrated resource management unit established in accordance with Section 7 of the *Forest Act*.
Tree farm licence (TFL)	Provides rights to harvest timber, and outlines responsibilities for forest management, in a particular area.

Unsalvaged losses	The volume of timber killed or damaged annually by natural causes (e.g., fire, wind, insects and disease) and not harvested.
Visual quality objective (VQO)	Defines a level of acceptable landscape alteration resulting from timber harvesting and other activities. A number of visual quality classes have been defined on the basis of the maximum amount of alteration permitted.
Volume estimates (yield projections)	Estimates of yields from forest stands over time. Yield projections can be developed for stand volume, stand diameter or specific products, and for empirical (average stocking), normal (optimal stocking) or managed stands.
Watershed	An area drained by a stream or river. A large watershed may contain several smaller watersheds.
Wildlife tree	A standing live or dead tree with special characteristics that provide valuable habitat for conservation or enhancement of wildlife.

Appendix A

Description of Data Inputs and Assumptions for the Timber Supply Analysis

Introduction

The following tables and discussion outline the methods and inputs used to derive the timber harvesting land base, and to construct the timber supply model for the Arrow TSA timber supply analysis. This information represents current forest management in the area.

Current management is defined as the set of land-use decisions and forest and stand management practices currently implemented and enforced. Future forest management objectives that may be intended, but are not currently implemented and enforced, are not included in this appendix.

The purpose of the Timber Supply Review is to provide information on the effects of current management on both short- and long-term timber supply in each timber supply area in the province. Any changes in forest management objectives and practices, and any improvements to the data will be included in subsequent timber supply analyses.

More detail on the derivation of many of the land base exclusions and modelling approaches is available in the January 1999 *Arrow Timber Supply Area Timber Supply Review Data Package*.

A.1 Inventory Information

Table A-1. Inventory information

Data	Source	Vintage	Update	Scale
Arrow TSA forest cover (FC1) and road network files	Ministry of Forests (MoF) standard inventory files	1973	1998	1:20 000
Operability (Cutblocks identified above the operability line will be included in the operable area)	MoF Forest District non-standard inventory files	1991	1997	1:20 000
Biogeoclimatic classification	MoF standard inventory files	1991-1992	1998	1:50 000
Caribou habitat	MoF Forest District non-standard inventory files	1998	N/A	1:250 000
Ungulate winter habitat (non-caribou)	MoF Forest District non-standard inventory files	1998	N/A	1:50 000 plus some at 1:20 000
Dewdney Trail	MoF Forest Region	1997	N/A	1:20 000
Known wildlife stick nests	Ministry of Environment, Lands and Parks (MELP)	1998		1:20 000
Landscape units and biodiversity emphasis objectives (declared April 8, 1998)	MoF Forest District non-standard inventory files	1996-1997	1998	1:250 000
KBLUP scenic corridors	LUCO	1998	1998	1:50 000
Visual landscape inventory	MoF non-standard inventory file	1995	1998	1:20 000
Watershed atlas (includes stream classification and community and domestic watersheds)	MoF Nelson Forest Region non-standard files	1997	N/A	1:20 000
Regionally significant fish streams	MELP	1998	N/A	1:20 000
Riparian management area mapping	MELP/MoF joint contract	1997	N/A	1:50 000
Slocan valley CORE sector review area	MoF Nelson Forest Region non-standard file	1991	N/A	1:20 000
Terrain hazard assessment	Arrow Forest District and licensees	1984-1998		Variable

Data source and comments:

Map bases were shifted to UTM NAD83 datum and TRIM line features were incorporated in 1997. Disturbance update was done to October 1998. Ownership was updated where necessary. Existing road right-of-way was updated for all roads within the Crown portion of the Arrow TSA not already accounted for by the forest cover inventory.

A.1 Inventory Information

Operability lines were revised in 1991. As part of the analysis for the *Kootenay-Boundary Land Use Plan* (KBLUP) a total chance plan was created in 1997 for eight landscape units in the Arrow TSA. This project is considered to constitute a review of operable areas under current harvesting guidelines. The operability line was also reviewed by the Innovative Forest Practices Agreement (IFPA) committee. Proposed harvest blocks located above the existing operability line were added to the timber harvesting land base.

The biogeoclimatic inventory was completed in 1992 and was updated in 1998. Natural disturbance types have been derived from the biogeoclimatic ecosystem classification (BEC) and the *Biodiversity Guidebook* (e.g., ESSF south of the Arrow Lakes is NDT 2).

The ungulate habitat overlay identifies important winter habitats for white tailed deer, mule deer and elk. Boundaries were based on elevation bands and the professional judgment of district and regional Ministry of Environment, Lands and Parks (MELP) staff.

Known wildlife stick nests are historic goshawk nests, which have a 200-metre reserve zone around them, and great blue heron nests, which have a 100-metre reserve zone around them.

Landscape unit boundaries and objectives, including biodiversity emphasis objectives, have been established by the Arrow Forest District Manager. Thirty-one landscape units have been established for the forest district with twenty-one contained within the Arrow TSA and the remainder in the Tree Farm Licences (TFL).

Scenic corridor classes were defined for the KBLUP implementation strategy. Visually sensitive areas in corridor classes 1, 2 and 3 have been assigned visual quality objectives.

Ministry of Forests and MELP regional staff recently reviewed the visual landscape inventory for the entire Nelson Forest Region. New standards and management guidelines associated with this inventory have been made known and are incorporated into the timber supply review (TSR).

The watershed atlas is a non-standard layer containing stream, wetland and lake information. It was the source for determining areas in the riparian reserve zone. This overlay also contains the boundaries of community and domestic watersheds. The watersheds feeding regionally significant fish bearing streams require management practices similar to domestic watersheds in order to protect the important fisheries.

Riparian management area classifications were intended to be based on detailed assessments carried out by qualified field personnel. However, the lack of quality-assured inventory information and the need to incorporate this resource into the analysis necessitated the development of a surrogate. In co-operation with MELP, an automated approach for classification was developed using that ministry's watershed atlas and TRIM digital elevation model. Using this automated process, streams and lakes were classified for the Arrow, Golden and Revelstoke Forest Districts in May 1997 by Nanuq Consulting Ltd. This surrogate was acceptable to the Nelson Forest Region and the Arrow Forest District staff.

The Commission on Resources and Environment (CORE) identified a significant portion of the Slocan valley for more detailed planning. This area incorporates the valley bottom and the face watershed units of Slocan Lake and Slocan River. The timber supply contribution of this area in the context of the TSA was examined. This area represents about 14% of the timber harvesting land base but has contribute less to harvests over recent years. In a sensitivity analysis, the rate of cut for the first decade will be modelled at the rate considered more likely to occur in practice.

Terrain hazard assessment surveys were carried out for operational planning. Where quality assurance standards have been met, this inventory will be used in addition to the primary and secondary ESA soil inventory in the forest cover files.

A.2 Zone and Analysis Unit Definition

A.2.1 Management zones (groups)

Table A-2. Group definition

Description	Inventory definition	Function
Landscape-level biodiversity — all forest	Non-standard mapped layer.	Application of biodiversity targets at the landscape unit/emphasis/BEC zone-variant level. All Crown forest included.
Caribou — ESSF	Non-standard mapped layer.	Application of ESSF caribou guidelines by landscape unit for the core caribou areas 1 and 2. Operable forest with less than 80% slope included.
Caribou — ICH	Non-standard mapped layer.	Application of ICH caribou guidelines by landscape unit for the core caribou areas 1 and 2. Operable forest with less than 80% slope included.
Visual quality	Non-standard mapped layer.	Application of visual quality objective (VQO) guidelines by landscape unit. Total forest included. Retention (R); Partial Retention (PR) and Modification (M) will be modelled.
Watersheds	Non-standard mapped layer.	Application of forest cover guidelines by landscape unit to community, domestic and regionally significant fish-bearing stream watersheds. All forested area included.
Ungulate winter range (UWR)	Non-standard mapped layer.	Application of ungulate winter range guidelines by landscape unit. Operable forest included.
Integrated resource management (IRM)	Crown forested, operable area where timber production is the primary objective.	Application of adjacency criteria by landscape unit. Timber harvesting land base included.
Slocan valley pilot area	Non-standard mapped layer.	Provide a means to do a sensitivity analysis on this area. Harvest rate was constrained to match harvest level most likely to occur.

Data source and comments:

See Section A.1, "Inventory information," for the sources of inventories referenced above.

A.2.2 Analysis units

An analysis unit represents a combination of stands dominated by specific tree species or a silvicultural regime with a specific timber growing capability — as indicated by the inventory type group and site index in the forest inventory file. Each analysis unit is assigned its own timber volume projections (yield tables) for existing and future stands.

Table A-3. Definition of analysis units

Analysis unit	Species	Area (hectares)	Inventory type groups	Site index range (metres)[a]	Age
Existing natural unmanaged thrifty stands					
11	F, L	11 167	1–8, 32–34	> 23	21 – 140
12	F, L	47 870	1–8, 32–34	17–23	21 – 140
13	F, L	11 777	1–8, 32–34	12 – < 17	21 – 140
31	C, H	2 135	9–17	> 20	11 – 140
32	C, H	7 638	9–17	16–20	11 – 140
33	C, H	5 563	9–17	8.5 – < 16	11 – 140
41	B	8 659	18–20	> 15.5	11 – 140
42	B	8 335	18–20	12 – < 15.5	11 – 140
43	B	2 280	18–20	8 – < 12	11 – 140
51	S	2 867	21–26	> 19	21 – 140
52	S	5 766	21–26	14.5 – 19	21 – 140
53	S	741	21–26	8 – < 14.5	21 – 140
71	P, Pa, Pw	6 536	27–31	> 20	11 – 140
72	P, Pa, Pw	21 682	27–31	14.5 – < 20	11 – 140
73	P, Pa, Pw	4 482	27–31	9.5 – < 14.5	11 – 140
Existing natural unmanaged old stands					
812	F, L	1 516	1-8, 32-34	> 17	> 140
813	F, L	3 685	1-8, 32-34	12 – < 17	> 140
832	C, H	1 006	9-17	> 16	> 140
833	C, H	9 767	9-17	8.5 – < 16	> 140
842	B	1 961	18-20	> 12	> 140
843	B	6 328	18-20	8 – < 12	> 140
852	S	2 103	21-26	> 14.5	> 140
853	S	4 835	21-26	8 – < 14.5	> 140
870	P, Pa, Pw	809	27-31	> 9.5	> 140
Existing managed stands					
112	F, L	4 931	1-8, 32-34	≥ 17	≤ 20
113	F, L	1 315	1-8, 32-34	12 – < 17	≤ 20
130	C, H	251	9-17	≥ 8.5	≤ 10
140	B	438	18-26	≥ 8	≤ 10
151	S	1 384	18-26	≥ 19	≤ 20
152	S	6 997	18-26	8 – < 19	≤ 20
171	Pl, Pa, Pw	558	27-31	≥ 20	≤ 10
172	Pl, Pa, Pw	2 422	27-31	14.5 – < 20	≤ 10
173	Pl, Pa, Pw	94	27-31	9.5 – > 14.5	≤ 10
Future managed stands from presently not satisfactorily restocked areas					
212	F, Pl, C	897	N/A	17 – 23[b]	≤ 5
232	F, S	548	N/A	16 – 20	≤ 5
233	F, S	181	N/A	8.5 – < 16	≤ 5
242	S, Pl, F	953	N/A	12 – 15.5	≤ 5
252	S, Pl, F	1 228	N/A	14.5 – 19	≤ 5
272	Pl, F, S	675	N/A	14.5 – 20	≤ 5

(a) Reference age is 50 years.

(b) Site index ranges for NSR correspond to the existing natural unmanaged thrifty stand units that match the last two digits of the NSR unit (i.e., 12 corresponds to 212).

A.3 Definition of the Timber Harvesting Land Base

A.3.1 Land not managed by the B.C. Forest Service

The ownership (OWN_CD) code on the inventory file was used to determine which areas were not managed by the B.C. Forest Service. This category includes areas such as parks, ecological reserves, private land and various special use permit areas. Forest with ownership codes 62 C (forest management unit) and 69 C (forest reserves) contributes to the TSA timber supply. Timber licence areas, ownership code 70N, become part of the timber harvesting land base after they have been harvested by the licensee and are returned to the B.C. Forest Service jurisdiction.

A.3.2 Non-forest land

Non-forest (TYPID_PR = 6) and non-typed (TYPID_PR = 8) areas do not contribute to timber harvesting. These categories include areas covered by such things as sparse alpine forest, ice, swamps, water, and rock.

A.3.3 Non-commercial (brush) cover

Non-commercial brush types (TYPID_PR = 5), were not included in the timber harvesting land base.

A.3.4 Inoperable areas

The inventory file contains an operability classification for Arrow TSA. All areas that were inoperable (OPERABLE = I or N) were excluded from the timber harvesting land base.

A.3.5 Environmentally sensitive areas (ESAs)

Some forest lands are environmentally sensitive and/or significantly valuable for other resources. These areas are identified and delineated during a forest inventory and are called environmentally sensitive areas (ESAs). The ESA system uses the following classification: soil (Es), forest regeneration problems (Ep), snow avalanche (Ea), recreation (Er), water (Eh), and wildlife (Ew). Two ESA categories are recognized: high (ESA1) and moderately (ESA2) sensitive. The following table lists the per cent of the area classified that was excluded from the timber harvesting land base. The percentage reductions are based on the history of harvesting activity carried on within the respective categories of ESAs.

Table A-4. Per cent of environmentally sensitive areas considered unavailable for harvesting

ESA category	ESA description	Outside community watersheds		Inside community watersheds	
		Reduction per cent ESA1	Reduction per cent ESA2	Reduction per cent ESA1	Reduction per cent ESA2
A	Avalanche	90	50	100	50
P	Regeneration	50	0	100	50
PR	Regeneration/recreation	50	0	100	50
R	Recreation	50	50	100	50
S	Soil	90	20	100	50
SA	Soil/avalanche	90	20	100	50
SP	Soil/plantation	90	20	100	50
SPW	Soil/plantation/wildlife	90	20	100	50
SR	Soil/recreation	90	20	100	50
SW	Soil/wildlife	90	20	100	50
	Terrain hazard survey Level A,B,C	80 Class V	25 Class IV	90 Class V	35 Class IV
	Level D	60 U (unstable)	20 P (potentially unstable)	90 U (unstable)	35 P (potentially unstable)

A.3.6 Sites with low timber growing potential

Sites may have low timber growing potential either because of inherent site factors (nutrient availability, exposure, excessive moisture, etc.), or because they are not fully occupied by commercial tree species. The stands excluded from the timber harvesting land base due to low timber growing potential are described in Table A-5.

Table A-5. Description of sites with low timber growing potential

Species	Characteristics	SI limit	Per cent (%) excluded
Fir/larch	Existing stands greater than age 140 with volumes less than 150 cubic metres/hectare and sites projected not capable of producing 150 cubic metres/hectare by age 140.	12	100
Cedar/hemlock	Existing stands greater than age 140 with volumes less than 150 cubic metres/hectare and sites projected not capable of producing 150 cubic metres/hectare by age 140.	8.5	100
Balsam	Existing stands greater than age 140 with volumes less than 150 cubic metres/hectare and sites projected not capable of producing 150 cubic metres/hectare by age 140.	8	100
Spruce	Existing stands greater than age 140 with volumes less than 150 cubic metres/hectare and sites projected not capable of producing 150 cubic metres/hectare by age 140.	8	100
Pine	Existing stands greater than age 140 with volumes less than 150 cubic metres/hectare and sites projected not capable of producing 150 cubic metres/hectare by age 140.	9.5	100

Data source and comments:

All sites which have been previously logged were included in the timber harvesting land base regardless of their site index.

A.3.7 Problem forest types

Problem forest types are species and types currently not utilized in the Arrow TSA. Generally, hemlock and balsam types greater than 140 years of age are not being harvested due to the high degree of decay. These stands may be physically operable and exceed low site criteria yet are not currently utilized. These types are wholly or partially excluded from the timber harvesting land base.

Table A-6. Problem forest types criteria

Species	Inventory type group	Age (years)	Per cent (%) reduction
C, H	11	> 140	50 (for Edgewood PSYU only)
H pure	12	> 140	40
B, BH	18-19	> 140	10
B, BH	18-19	> 250	100
Pl	28; Proj. Ht. Class 2 (10.5-19.4 m); Proj. Stocking Class > = 2; Site Class = P	> 100	90
Deciduous	35-42	All	100

A.3 Definition of the Timber Harvesting Land Base

A.3.8 Riparian reserves and management zones

A geographic information system (GIS) analysis was performed to classify all streams, wetlands and lakes on the basis of slope and width. The resultant data was produced by stream class and length and added to the inventory file. The riparian area indicated in Table A-7. is part of the inventory data and was excluded from the timber harvesting land base.

Table A-7. Riparian areas

Stream class	Reserve zone width (metres)	Management zone width (metres)	Retention in management zone (%)	Total riparian reduction area (metres)
S1	50	20	50	60
S2	30	20	50	40
S3	20	20	50	30
S4	0	30	25	8
S5	0	30	25	8
W1	10	40	25	20
W3	0	30	25	8
W5	10	40	25	20
L1	10	0	0	10

Data source and comments:

The riparian reduction area is applied to each side of the watercourse. The total riparian reduction area consists of the riparian reserve zone plus the riparian management zone. The total riparian reduction area is made up of the reserve zone plus the management zone multiplied by the retention percentage.

A.3.9 Existing and future unclassified roads, trails, and landings

A separate road overlay was created to account for the roads and skid trails not already shown in the forest cover inventory. Table A-8. shows the right-of-way widths assumed for existing roads and trails as well as the reductions made for existing landings and future roads, trails and landings.

Table A-8. Estimates for existing and future roads, trails and landings

Location	Age (years)	Road width (metres)	Reduction area (hectares) or per cent (%)
Existing RTLs			
Roads		15	
Trails		4	
Landings	Less than 40	N/A	3%
Future RTLs			
Roads	Greater than 40		3%
Trails	Greater than 40		2%
Landings	Greater than 40		2.4%

Data source and comments:

Existing landing reductions were estimated at 3% of the timber harvesting land base based on a review of year-end forest disturbance reports.

Future road, trail and landing reductions were projected to be similar to recent reductions. These were calculated through a review of year-end forest disturbance reports. The reductions apply to the timber harvesting land base after the stands currently greater than 40 years old have been harvested.

A.3.10 Wildlife stick nests

Whenever goshawk or great blue heron nests are encountered in the Arrow TSA, a reserve zone is established to preserve the nesting habitat. For goshawks the reserve zone is 200 metres, and for great blue heron the reserve zone is 100 metres. Known nests were identified on a map overlay and the reserve zones were removed from the timber harvesting land base.

A.3.11 Cultural heritage resource reductions

The Dewdney Trail has been established as a Heritage trail through portions of the Arrow TSA. In order to preserve the trail, timber within the trail corridor will not be available for regular scheduled harvesting, except in emergency situations such as disease or insect infestations, and fire. A 100-metre reserve on both sides of the trail (a 200-metre wide reserve in total) has been established.

A.3.12 Stand-level biodiversity reductions

Wildlife tree patches are retained on cutblocks within the Arrow TSA to provide for the maintenance of stand structure over time. Arrow Forest District staff calculated that 7% of the forested area in each landscape unit is required for stand-level biodiversity. It was estimated that one-half of this target can be met from forest outside of the timber harvesting land base. Consequently, the timber harvesting land base was reduced by 3.5% to account for stand-level biodiversity management.

A.3.13 Timber licence reversions

Timber licence TO467 is the only remaining licence in the Arrow TSA. This timber licence is held by Riverside Forest Products Ltd. and will revert to the Crown in 2045. Approximately 19% of the timber licence area falls within the Columbia Forest District with the remaining 81% falling within the Arrow Forest District. After expiration of the licence each respective forest district will administer the area within its boundaries.

The forest inventory file shows a total of 2229 hectares of timber licences in the Arrow TSA. After accounting for area removals such as ESAs and low site, TO467 covers approximately 817 hectares of timber harvesting land base in the Arrow TSA. Table A-9. shows how this area was returned to the B.C. Forest Service jurisdiction over time.

Table A-9. Timber licence harvest schedule

Reverting timber licence area (hectares) by decade				
1998-2000	2000-2010	2010-2020	2020-2030	2030-2040
181	161	189	141	145

A.4 Forest Management Assumptions

A.4.1 Utilization levels

The utilization level defines the maximum allowable stump height, and the diameters at breast height (1.3 metres) and at the top of the tree used to calculate merchantable timber volumes.

In the Arrow TSA, according to licence requirements and current performance, timber is currently utilized as outlined in Table A-10.

Table A-10. Utilization levels

	Utilization		
Analysis unit	**Minimum dbh (cm)**	**Maximum stump height (cm)**	**Minimum top dib (cm)**
All pine units	12.5	30	10
All other conifer units	17.5	30	10

A.4.2 Volume exclusions for mixed species stands

All deciduous species were excluded from the estimation of volume in coniferous-leading mixed species stands. All stands dominated by deciduous species were excluded from the timber harvesting land base (see Section A.3.7, "Problem forest types").

A.4.3 Minimum harvestable ages

Minimum harvestable age defines the earliest age at which a stand may be harvested, not the age at which harvesting must occur. For this analysis, minimum harvestable ages were defined by the age at which stands attained a volume of 150 cubic metres per hectare and when the average stem diameter at breast height was 25 centimetres. In all cases, the volume criteria produced the higher minimum harvestable age. For managed stands the average diameter of the largest 250 stems was used, whereas the average diameter of all stems was used for unmanaged stands. Table A-11. shows the minimum harvestable ages as well as the culmination ages for the analysis units used in this TSA.

Table A-11. Minimum harvestable ages

Analysis unit	Species	Minimum harvestable age (years)	Culmination age (years)
Existing natural unmanaged thrifty stands			
11	F, L	60	100
12	F, L	80	120
13	F, L	100	130
31	C, H	60	80
32	C, H	60	90
33	C, H	90	130
41	B	70	100
42	B	90	110
43	B	150	160
51	S	60	90
52	S	80	110
53	S	120	160
71	P, Pa, Pw	90	70
72	P, Pa, Pw	110	90
73	P, Pa, Pw	140	130
Existing natural unmanaged old stands			
812	F, L	70	110
813	F, L	110	130
832	C, H	70	90
833	C, H	90	130
842	B	90	110
843	B	140	160
852	S	70	100
853	S	120	150
870	P, Pa, Pw	130	120
Existing managed stands			
112	F, L	60	110
113	F, L	80	130
130	C, H	65	100
140	B	75	120
151	S	55	90
152	S	80	120
171	Pl, Pa, Pw	50	80
172	Pl, Pa, Pw	70	100
173	Pl, Pa, Pw	120	160
Future managed stands			
211	F, Pl, C	40	80
212	F, Pl, C	55	110
213	F, Pl, C	80	120
231	F, S	50	90
232	F, S	70	110
233	F, S	115	160
241	S, Pl, F	60	100
242	S, Pl, F	80	120
243	S, Pl, F	110	160
251	S, Pl, F	50	80
252	S, Pl, F	70	110
253	S, Pl, F	110	160
271	Pl, F, S	45	80
272	Pl, F, S	60	100
273	Pl, F, S	90	130

A.4.4 Harvest scheduling

Priority for harvest was highest for stands that were the oldest relative to the applicable minimum harvestable age. This is termed a "relative oldest first" harvest rule.

A.4.5 Unsalvaged losses

Table A-12. summarizes the estimate for unsalvaged losses in the Arrow TSA used in this analysis. Timber volume losses to insects and diseases that normally occupy stands (so-called endemic losses) are accounted for in inventory sampling for timber yield estimation. The purpose of the unsalvaged losses estimate is to account for catastrophic events and other factors not recognized in yield estimates.

Table A-12. Unsalvaged losses

Cause of loss	Annual unsalvaged loss (m^3/year)
Mountain pine bark beetle	14 200
Douglas-fir bark beetle	500
Disease (year 1)	5 720
Disease (year 95)	0
Wildfire	5 800
Windthrow/blowdown	2 500
Total loss	**28 720**

Data source and comments:

Information regarding unsalvaged losses was collected from Arrow Forest District staff, licensees, the fire protection reporting system, Major License Silvicultural Information System (MLSIS) / Integrated Silviculture Information System (ISIS) (harvesting databases), annual reports, and Forest Insect Disease Survey (FIDS) reports. This information was modified using professional judgment to produce the data in Table A-12. A permanent database has been constructed to update unsalvaged losses on an annual basis and to provide more accurate results for preparing future timber supply review data packages.

A.4.6 Managed stands and regeneration assumptions

Existing managed stands are those areas of immature forest where the density (stems per hectare) was controlled which justifies assigning the stands to managed stand yield tables (MSYT). Douglas-fir and spruce stands less than 20 years old are considered managed stands due to the longer history of density control in these stands. Density contro! and tending has only occurred over the last 10 years in all other stand types in the Arrow TSA. Table A-13. shows the criteria for the selection of existing managed stands.

Table A-13. Existing managed stands

Analysis unit	Composition	Site index	Area managed (%)	
			Age 1 - 10	Age 11 - 20
112	All Douglas-fir, larch	≥ 17	100	100
113	All Douglas-fir, larch	12 – < 17	100	100
130	All cedar and hemlock	≥ 8.5	100	
140	All balsam	≥ 8	100	
151	All spruce	≥ 19	100	100
152	All spruce	8 – < 19	100	100
171	All pine	≥ 20	100	
172	All pine	14.5 – < 20	100	
173	All pine	9.5 – < 14.5	100	

Density control is also planned for all future regenerated stands which will be assigned to managed stand yield tables. Table A-14. shows the regeneration assumptions by analysis unit.

Table A-14. Regeneration assumptions by analysis unit

Analysis unit	Composition	Regen delay (years)	Regen method	Regen analysis unit	Regen species	Per cent (%)	Density initial (sph)
11	F, L	2	Plant	211	F	50	1200
					Pl	30	
					C	20	
12, 812	F, L	2	Plant	212	F	50	1200
					Pl	30	
					C	20	
13, 813	F, L	2	Plant	213	F	50	1200
					Pl	35	
					S	15	
31	C, H	2	Plant	231	F	60	1200
					S	40	
32, 832	C, H	2	Plant	232	F	60	1200
					S	40	
33, 833	C, H	2	Plant	233	F	60	1200
					S	40	
41	B	2	Plant	241	S	60	1200
					Pl	25	
					F	15	
42, 842	B	2	Plant	242	S	60	1200
					Pl	25	
					F	15	
43, 843	B	2	Plant	243	S	60	1200
					Pl	25	
					F	15	
51	S	2	Plant	251	S	60	1200
					Pl	25	
					F	15	
52, 852	S	2	Plant	252	S	60	1200
					Pl	25	
					F	15	
53, 853	S	2	Plant	253	S	60	1200
					Pl	25	
					F	15	
71	P, Pa, Pw	2	Plant	271	Pl	50	1200
					F	30	
					S	20	
72	P, Pa, Pw	2	Plant	272	Pl	50	1200
					F	30	
					S	20	
73, 870	P, Pa, Pw	2	Plant	273	Pl	50	1200
					F	30	
					S	20	
112, 113	F, L	2	Plant	112, 113	F	50	1200
					Pl	30	
					C	20	
130	C, H	2	Plant	130	F	60	1200
					S	40	

continued

Table A-14. Regeneration assumptions by analysis unit (concluded)

Analysis unit	Composition	Regen delay (years)	Regen method	Regen analysis unit	Regen species	Per cent (%)	Density initial (sph)
140	B	2	Plant	140	S	60	1200
					Pl	25	
					F	15	
151, 152	S	2	Plant	151, 152	S	60	1200
					Pl	25	
					F	15	
171, 172, 173	Pl, Pa, Pw	2	Plant	171, 172, 173	Pl	50	1200
					F	30	
					S	20	

Data source and comments:

Regeneration delay reflects current operational practice and is defined as the time after harvest but before planting.

Provincial average operational adjustment factors (OAFs) were applied to the managed stand yield curves as recommended by the Ministry of Forests, Research Branch — since no local factors were available. OAF1 (15%) reflects small stocking gaps in stands, while OAF2 (5%) reflects the estimate for decay, waste and breakage that increases with age, passing through 5% at 100 years of age.

A.4.7 Not satisfactorily restocked (NSR) areas

Forest district silviculture records (ISIS and MLSIS) showed 2001 hectares of backlog NSR (i.e., harvested prior to 1987) and 2012 hectares of current NSR. The forest inventory file indicated that there were 5844 hectares of NSR. The difference (1831 hectares), was assumed to have already been restocked and assigned an age between one and five years old. Current NSR was assumed to regenerate within the regeneration delays provided in Table A-14., and was restocked in proportion to the current area of each analysis unit in stands less than 20 years old. In the analysis it was assumed that 70% of the backlog NSR will be restocked within 10 years and the remainder at a constant rate over the subsequent 60 years.

A.4.8 Forest cover requirements — resource emphasis areas

The timber supply model used in this analysis (FSSIM Version 3.0) can incorporate forest cover requirements that specify both the maximum proportion of an area allowed in a disturbed condition, and the minimum required area of old-age forest. The forest cover requirements applied in the analysis approximate current forest management practices. The following forest cover requirements were applied to each resource emphasis group within each landscape unit.

Table A-15. Forest cover requirements for resource emphasis areas

Resource emphasis	Forest cover objectives				
	Green-up height (metres)	Green-up maximum allowable disturbance %	Minimum older age (years)	Minimum area of older age retained (%)	Land base constraints apply to
Caribou ESSF	2	25	140 250	37 10	Operable area below 80% slopes
Caribou ICH	2	25	140 250	40 10	Operable area below 80% slopes
Visual quality — retention	7	5	N/A	N/A	Crown forested area
Visual quality — partial retention	7	15	N/A	N/A	Crown forested area
Visual quality — modification	6	25	N/A	N/A	Crown forested area
Class 1 domestic watersheds	6	15	N/A	N/A	Crown forested area
Community and class 2 domestic watersheds	6	20	N/A	N/A	Crown forested area
Class 3 domestic watersheds	6	25	N/A	N/A	Crown forested area
Regionally significant fish streams	6	25	N/A	N/A	Crown forested area
Integrated resource management	2	25	40	70	Timber harvesting land base
Ungulate winter range	2	25	100	40	Operable area

A.4.9 Forest cover requirements — landscape-level biodiversity

The process to establish landscape units and biodiversity objectives for each landscape unit is complete and the landscape unit boundaries and emphasis options have been declared. Of the thirty-one landscape units in the Arrow Forest District twenty-one are in the Arrow TSA; the remainder are in Tree Farm Licences.

In order to ensure that older forest will be present throughout the TSA the following forest cover requirements were applied to the landscape units. These forest cover requirements are in accordance with the guidelines established in the *Biodiversity Guidebook* and the *Landscape Unit Planning Guide*, agreements made under KBLUP, and a letter dated August 25, 1997, from the deputy ministers of the Ministry of Forests and the Ministry of Environment, Lands and Parks to field operations staff regarding *Achieving Acceptable Biodiversity Timber Impacts*.

Table A-16. Forest cover requirements for resource emphasis areas

			Old-seral stage					
			Mature and old-seral stage		Minimum retention area (%)			
Biogeoclimatic unit	NDT	Biodiversity emphasis	Minimum retention area (%)	Minimum age (years)	Now	71 years	141 years	Minimum age (years)
ESSF	1	Low	19	120	6.3	12.7	19	250
ESSF	1	Medium	36	120	19	19	19	250
ESSF	1	High	54	120	28	28	28	250
ESSF	2	Low	14	120	3	6	9	250
ESSF	2	Medium	28	120	9	9	9	250
ESSF	2	High	42	120	13	13	13	250
ICH	1	Low	17	100	4.3	8.7	13	250
ICH	1	Medium	34	100	13	13	13	250
ICH	1	High	51	100	19	19	19	250
ICH	2	Low	15	100	3	6	9	250
ICH	2	Medium	31	100	9	9	9	250
ICH	2	High	46	100	13	13	13	250
ICH	3	Low	14	100	4.6	9.4	14	140
ICH	3	Medium	23	100	14	14	14	140
ICH	3	High	34	100	21	21	21	140
ICH/IDF	4	Low	17	100	4.3	8.7	13	250
ICH/IDF	4	Medium	34	100	13	13	13	250
ICH/IDF	4	High	51	100	19	19	19	250

A.4 Forest Management Assumptions

For each landscape unit the following biodiversity emphases were applied to the biogeoclimatic (BEC) variants.

Table A-17. Biodiversity emphasis by landscape unit and BEC variant for the Arrow Forest District

Landscape unit	BEC variant	Biodiversity emphasis	Landscape unit	BEC variant	Biodiversity emphasis
N501	ICHdw ESSF ICHmw2	Medium Medium Low	N516	All	Low
N502	All	Low	N517	All	Low
N503	All	Low	N518	ICHdw Others	Medium Low
N504	All	Medium	N519	ESSF Other	Medium Low
N505	All	Medium	N520	ESSF Other	Medium Low
N506	All	Low	N521	All	Medium
N507	All	Low	N522	All	Medium
N508	ICHdw Others	Medium Low	N523	All	Medium
N509	All	Medium	N524	All	Medium
N510	All	Medium	N525	All	High
N511	All	Medium	N526	All	Low
N512	All	Low	N527	ESSF Other	Medium Low
N513	All	Medium	N528	ESSF Other	High Medium
N514	All	Medium	N529	ESSF Other	High Medium
N515	All	High	N530	All	High
			N531	All	Low

A.5 Volume Estimates for Existing Stands

The variable density yield projection (VDYP) model, Version 6.5a developed and supported by the B.C. Ministry of Forests, Resources Inventory Branch, was used to estimate timber volumes for existing natural stands. Table A-18. shows the volume estimates by analysis unit for existing natural stands.

Table A-18. Timber volume tables for existing natural stands (cubic metres/hectare)

Age (years)	Analysis unit								
	11	12	13	31	32	33	41	42	43
10	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0
30	21	4	0	12	3	0	8	0	0
40	63	33	6	78	49	2	40	12	0
50	109	69	27	140	110	18	84	41	7
60	154	106	54	195	164	50	124	74	20
70	198	142	80	242	212	88	163	108	42
80	239	177	106	283	255	125	196	136	61
90	278	210	131	315	288	157	225	159	78
100	312	241	156	340	316	185	250	181	93
110	343	270	179	361	340	209	273	200	107
120	371	296	200	377	359	230	293	217	119
130	397	320	220	398	382	253	316	237	133
140	419	340	238	416	402	273	337	255	146
150	435	356	251	432	419	291	356	272	159
160	448	368	262	446	435	307	373	287	171
170	457	378	270	458	448	321	389	302	182
180	465	385	276	469	460	334	404	316	193
190	472	392	283	480	471	345	418	329	203
200	479	399	289	489	482	357	432	341	213
210	486	406	295	498	492	368	445	354	222
220	492	412	301	508	502	379	457	365	232
230	498	418	306	516	511	389	469	376	241
240	503	424	311	525	520	399	481	387	249
250	508	429	316	532	528	409	492	397	257
260	509	430	317	534	530	413	494	399	259
270	509	430	317	536	533	418	496	401	261
280	509	431	318	538	535	421	497	403	263
290	510	431	318	539	537	424	499	405	264
300	510	432	319	540	538	427	501	406	266
310	510	432	319	542	540	430	502	408	267
320	510	432	320	543	542	432	503	409	268
330	510	432	320	544	543	435	505	410	270
340	510	433	320	545	544	437	506	412	271
350	510	433	320	546	546	439	507	413	272

(continued)

A.5 Volume Estimates for Existing Stands

Table A-18. Timber volume tables for existing natural stands (cubic metres/hectare)

Age (years)	Analysis unit								
	51	52	53	71	72	73	812	813	832
10	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0
30	0	0	0	44	12	0	3	0	2
40	38	3	0	102	57	10	35	6	49
50	105	30	1	154	98	39	77	24	110
60	163	79	8	200	136	69	119	48	165
70	213	123	31	239	169	96	160	73	213
80	256	162	60	273	198	121	199	97	257
90	290	196	87	304	225	145	234	120	289
100	318	226	111	331	250	167	268	141	316
110	342	252	133	356	272	188	299	162	338
120	362	274	154	378	293	207	325	180	355
130	381	295	174	400	313	226	350	198	379
140	397	314	193	415	327	239	372	214	401
150	411	329	210	426	337	249	391	227	421
160	423	343	225	433	345	257	407	238	439
170	432	355	239	438	349	262	420	247	455
180	441	365	252	440	351	264	432	256	470
190	448	373	263	439	350	264	444	264	483
200	455	382	274	442	352	267	455	271	497
210	462	389	284	445	355	270	465	279	510
220	467	396	294	448	358	273	475	286	523
230	472	402	302	451	361	276	484	292	536
240	477	408	311	454	363	278	493	299	549
250	481	413	318	457	366	281	501	304	560
260	483	416	323	459	367	283	503	305	563
270	484	419	327	460	369	284	504	306	565
280	486	421	330	462	371	286	505	307	567
290	487	423	334	464	372	288	506	308	569
300	488	425	337	465	374	289	507	308	570
310	489	426	339	467	375	290	508	309	572
320	489	428	342	468	376	291	509	310	573
330	490	429	344	469	377	292	509	310	574
340	490	430	346	470	378	293	510	311	576
350	491	431	348	471	379	294	511	311	577

(continued)

A.5 Volume Estimates for Existing Stands

Table A-18. Timber volume tables for existing natural stands (cubic metres/hectare) (concluded)

Age (years)	Analysis unit					
	833	842	843	852	853	870
10	0	0	0	0	0	0
20	0	0	0	0	0	0
30	0	0	0	0	0	2
40	2	10	0	10	0	16
50	20	35	7	48	1	48
60	54	68	23	102	11	82
70	93	102	47	150	32	113
80	131	129	68	191	58	141
90	163	152	87	226	86	166
100	190	173	104	255	112	189
110	214	192	119	281	136	210
120	233	208	133	302	157	229
130	256	227	148	323	178	248
140	276	244	162	341	196	262
150	294	261	175	356	213	273
160	310	276	188	370	229	282
170	324	291	200	382	243	289
180	337	305	212	393	256	294
190	348	318	222	402	268	296
200	360	331	233	410	279	300
210	371	343	243	418	289	305
220	382	355	253	425	299	309
230	393	366	262	431	308	313
240	403	377	271	437	316	317
250	412	387	280	442	323	320
260	416	389	282	445	328	322
270	420	391	284	448	332	324
280	424	393	286	450	336	326
290	427	395	288	452	339	328
300	430	397	290	454	342	329
310	433	399	292	455	345	330
320	435	400	293	457	348	331
330	438	402	295	458	350	332
340	440	403	296	459	352	333
350	442	404	298	459	354	334

A.6 Volume Estimates for Regenerated Stands

WinTIPSY (Windows™ version of the Table Interpolation Program for Stand Yields) version 1.4, supported by the B.C. Ministry of Forests, Research Branch, was used to estimate growth and yield for existing and future managed stands. The area-weighted site index for each analysis unit along with the regeneration assumptions in Table A-14. were used as inputs to TIPSY. Tables A-13. and A-14. in Section A.4.6 document which stands were assumed to be managed in the analysis.

Table A-19. displays the volume tables for managed stands. These volume tables are generated from TIPSY for ages where TIPSY data exists, and estimated for ages beyond the TIPSY data set. Volumes are assumed to remain constant after 300 years of age.

A.6 Volume Estimates for Regenerated Stands

Table A-19. Timber volume tables for existing and future managed stands (cubic metres/hectare)

Age (years)	Analysis unit							
	140	241	242	243	130	231	232	233
10	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
30	0	3	0	0	0	2	0	0
40	8	24	4	0	13	58	7	0
50	35	79	19	1	68	151	49	1
60	86	152	57	7	140	237	113	5
70	145	217	106	22	202	315	174	19
80	197	277	159	49	262	375	229	44
90	244	329	202	82	315	428	280	75
100	291	370	243	117	355	473	323	106
110	327	402	283	152	391	506	358	137
120	357	428	316	180	423	532	389	164
130	381	450	342	207	451	553	416	188
140	400	469	363	233	473	569	440	212
150	417	482	381	259	491	582	460	234
160	432	494	396	281	504	593	476	252
170	444	499	409	300	517	602	488	269
180	454	503	420	316	528	602	498	283
190	463	506	431	328	535	602	508	296
200	471	506	439	340	542	602	516	307
210	475	506	445	349	549	602	523	317
220	477	506	451	357	553	602	528	326
230	478	506	457	365	556	602	532	333
240	478	506	459	371	559	602	536	340
250	479	506	459	377	562	602	539	346
260	478	506	460	382	564	602	541	352
270	478	506	461	386	565	602	542	357
280	477	506	461	390	565	602	543	361
290	477	506	462	393	565	602	545	365
300	477	506	462	393	565	602	545	365
310	477	506	462	393	565	602	545	365
320	477	506	462	393	565	602	545	365
330	477	506	462	393	565	602	545	365
340	477	506	462	393	565	602	545	365
350	477	506	462	393	565	602	545	365

(continued)

A.6 Volume Estimates for Regenerated Stands

Table A-19. Timber volume tables for existing and future managed stands (cubic metres/hectare)

Age (years)	Analysis unit							
	112	113	211	212	213	171	172	173
10	0	0	0	0	0	0	0	0
20	0	0	4	0	0	1	0	0
30	5	0	66	9	0	39	6	0
40	40	7	179	59	7	107	34	1
50	102	32	283	130	31	178	77	11
60	167	74	381	202	70	245	122	28
70	226	117	467	260	112	300	165	50
80	272	158	467	314	153	352	204	74
90	318	195	467	365	189	394	239	99
100	361	226	467	412	221	430	272	121
110	399	254	467	454	250	459	299	142
120	435	277	467	488	275	481	322	161
130	465	301	467	516	297	499	342	178
140	490	323	467	544	316	499	359	195
150	511	342	467	544	332	499	374	210
160	531	359	467	544	347	499	389	225
170	551	375	467	544	362	499	401	237
180	569	390	467	544	374	499	411	248
190	569	404	467	544	386	499	420	257
200	569	415	467	544	395	499	428	266
210	569	425	467	544	403	499	436	273
220	569	435	467	544	411	499	440	280
230	569	444	467	544	418	499	445	284
240	569	453	467	544	424	499	447	289
250	569	460	467	544	428	499	449	293
260	569	467	467	544	432	499	450	297
270	569	473	467	544	434	499	451	300
280	569	479	467	544	436	499	452	303
290	569	483	467	544	438	499	453	306
300	569	483	467	544	438	499	453	306
310	569	483	467	544	438	499	453	306
320	569	483	467	544	438	499	453	306
330	569	483	467	544	438	499	453	306
340	569	483	467	544	438	499	453	306
350	569	483	467	544	438	499	453	306

(continued)

Table A-19. Timber volume tables for existing and future managed stands (cubic metres/hectare) (concluded)

Age (years)	Analysis unit							
	271	272	273	151	152	251	252	253
10	0	0	0	0	0	0	0	0
20	4	0	0	0	0	0	0	0
30	51	14	1	7	0	16	1	0
40	129	55	11	43	5	78	13	0
50	207	110	34	118	22	176	52	2
60	275	161	66	200	64	260	112	9
70	337	211	100	269	116	341	176	27
80	389	254	132	334	169	400	230	58
90	433	292	161	383	213	444	281	93
100	466	325	188	420	255	478	325	130
110	493	354	212	450	296	478	360	163
120	493	377	235	475	327	478	388	193
130	493	399	256	493	352	478	410	220
140	493	417	274	508	373	478	429	247
150	493	434	289	508	390	478	446	273
160	493	448	301	508	405	478	460	294
170	493	458	312	508	418	478	471	312
180	493	466	322	508	430	478	481	326
190	493	472	331	508	439	478	485	339
200	493	477	339	508	447	478	487	350
210	493	482	345	508	454	478	489	359
220	493	486	351	508	460	478	491	367
230	493	490	357	508	463	478	492	374
240	493	490	362	508	464	478	493	380
250	493	490	336	508	465	478	493	385
260	493	490	370	508	466	478	493	390
270	493	490	374	508	467	478	493	395
280	493	490	377	508	467	478	493	398
290	493	490	379	508	465	478	493	400
300	493	490	379	508	465	478	493	400
310	493	490	379	508	465	478	493	400
320	493	490	379	508	465	478	493	400
330	493	490	379	508	465	478	493	400
340	493	490	379	508	465	478	493	400
350	493	490	379	508	465	478	493	400

Appendix B

Socio-Economic Analysis Background Information

B.1 Limitations of Economic Analysis

The socio-economic analysis of this report identifies employment and income impacts, changes in government revenues and community impacts due to changes in the TSA's harvest levels over time. Some of the assumptions used in this report are as follows:

- **Employment multipliers** — employment multipliers are used to estimate indirect and induced employment impacts of a change in direct industry activity. The calculation of employment multipliers is based on analytical assumptions and data collected at a specific time period. The multipliers reflect industry and employment conditions at that time and may not accurately reflect industry and employment conditions in the future.
- **Employment coefficients** — employment coefficients are ratios of person-years of employment per 1000 cubic metres of timber harvested. These ratios are used to estimate employment levels associated with alternative harvest rates. This method of analysis assumes that the industry structure will be the same in the future as it is today. While reasonably accurate in the short term, employment coefficients may change in the future due to changes in market conditions, product mix or production technologies.
- **Timing of impacts** — employment impacts are shown to occur simultaneously with a change in the harvest level. While this is reasonably accurate for the harvesting sub-sector, employment estimates for the silviculture and timber processing sub-sectors may not be as coincidental. As well, indirect and induced impacts tend to occur over a longer period, as levels of business and consumer spending adjust to changes in harvest levels.
- **Operating thresholds of mills** — the impacts on timber processing employment due to changes in harvest levels are unlikely to be in direct proportion to the harvest changes (i.e., a 10% change in harvest may not lead to a 10% change in timber processing employment). Impacts on timber processing employment are more likely to occur in a stepwise manner related to operating thresholds of mills. For example, if a mill's timber supply is reduced, its operating threshold is reached when the decrease in timber supply causes it to lay off a shift of workers or to close the mill, either temporarily or permanently. Conversely, if the timber supply to the mill is increased, a processing threshold is reached when the mill must decide whether to add another shift of workers or new capacity to process the increase in timber supply. In both cases, the per cent change in employment in the mill would probably differ from the per cent change in the timber processed. Because mills have many different operating configurations, accurate predictions of an individual mill's operating threshold are not possible. As a result, impact figures pertaining to employment in timber processing are best interpreted as size of change rather than as precise changes in employment levels.
- **Government expenditures** — provincial government expenditures are more related to government policy and population levels than to industry activity. As such, expenditures on education, health care and other government services are assumed to remain unchanged despite changes to the harvest level and subsequent changes in government revenues from the forestry sector. However, provincial government expenditures would likely change if a community's population changes significantly. This would amplify the community impacts of losses or gains in forestry sector jobs.
- **Proportional harvest reductions** — harvest reductions are assumed to be proportionately distributed among all licensees and all forms of tenure within the TSA.

B.2 Economic Impact Analysis Methodology

Data sources

Data for the socio-economic analysis were obtained from several sources. Harvest volume and stumpage data are from the Ministry of Forests. Timber low and employment data are from responses to questionnaires that were sent to licensees, operators and processing facilities in the TSA. Other general economic data are from BC STATS, the Ministry of Finance and Corporate Relations, Statistics Canada and local communities. Estimates of taxes paid by the forest industry are from Price Waterhouse Coopers (1999).

Person-year of employment

The unit of measurement for employment is a person-year. A person-year of employment is defined as a full-time job that lasts at least 180 days per year. Part-time jobs were converted to equivalent full-time person-years of employment.

To estimate employment and income impacts associated with changes in TSA timber harvest levels, the forest sector was divided into three sub-sectors:

1) harvesting;

2) silviculture; and,

3) timber processing.

Employment and income impacts were estimated in several steps. The first step was to assess current activity in each of the three sub-sectors. Then, indirect and induced employment and employment income impacts were estimated using data from Ministry of Finance and Corporate Relations (1996) and Statistics Canada. Next, employment coefficients were calculated and applied to the base case harvest forecast. Other indicators of the forest sector's contribution to the provincial economy, such as government revenues and industry taxes, were also calculated using Ministry of Forests stumpage estimates and other data sources.

Employment — harvesting

Direct employment in harvesting consists of all woodlands-related jobs including harvesting, log salvage, planning and administration functions and log transportation. The employment multipliers used in this analysis define activities such as road building or maintenance work as indirect rather than direct employment because these are services that the forest sector and other basic sectors purchase.

Data on employment, place of residence and timber flows were obtained from responses to questionnaires that were sent to licensees and operators in the TSA. The information was then used to estimate employment averages associated with harvest changes and the proportion of resident versus non-residents who work in the TSA.

Two estimates of direct employment in harvesting were calculated:

1) TSA direct employment in harvesting consists of employees who are engaged in harvesting and related activities within the TSA and who reside in communities within the TSA; and,

2) Provincial direct employment in harvesting consists of employees who are engaged in harvesting, as above, plus those workers who reside outside the TSA, but come to the TSA to work in harvesting and harvesting related activities.

The estimates of TSA and provincial direct employment in harvesting were used to calculate employment coefficients per 1000 cubic metres. These employment coefficients were then used to estimate harvesting employment associated with the different harvest levels in the base case forecast.

Employment — silviculture

Silviculture employment consists of all basic and intensive reforestation activities, including surveys, site preparation, planting, fertilization, pruning and spacing. Silviculture employment data were collected from the Ministry of Forests and licensees whose tenures require post-harvest silviculture work. Most silviculture work is seasonal and silviculture employees usually only work part time during the year. Because of this, information on silviculture employment was converted into equivalent full-time person-years of employment. Respondents were also asked to estimate the percentage of their silviculture employees who resided within the TSA and outside the TSA.

As with the harvesting sub-sector, two estimates of direct employment in silviculture were calculated: one for the TSA and another for the province. These employment figures were used to calculate employment coefficients for silviculture employment in the same manner as the employment coefficients for harvest employment.

Employment — timber processing

Information was gathered from mills pertaining to their employment, production and sources of timber. Information was also gathered as to whether timber harvested from the TSA was processed within or outside the TSA. This information indicates the degree of dependence the mills have on timber harvested within the TSA. To estimate the share of processing employment supported by TSA timber, mill employment was prorated by the relative contribution of timber from the TSA to a mill's total timber requirement. For example, if 80% of a plant's timber supply is from the harvest of the TSA, then 80% of the employment in the plant would be attributable to the TSA harvest. Employment figures were also adjusted to reflect whether workers lived within or outside the TSA. Employment in timber processing that is supported by chip by-products from milling operations was similarly estimated.

As with the harvesting sub-sector, two estimates of direct employment in timber processing were calculated: one for the TSA and another for the province. These employment figures were used to calculate employment coefficients for timber processing employment in the same manner as the employment coefficients for harvest employment.

Indirect and induced employment estimates

Indirect employees in the forest sector provide goods and services to firms directly engaged in the basic forest sector (for example, those who build or maintain road for log transport). Induced employees provide the goods and services purchased by employees who are directly and indirectly engaged in the industry (for example, those who work in retail outlets). Indirect and induced employment figures were calculated using TSA and provincial employment multipliers developed by the Ministry of Finance and Corporate Relations.

Two sets of employment multipliers were calculated for this report: a migration multiplier and a no-migration multiplier. The migration multipliers assume that displaced workers will leave the region, reducing total income in the region by their full wage. The no-migration multipliers assume that a displaced worker remains in the area, at least in the short term, and unemployment and other social safety net payments temporarily offset some of the income loss. Using the no-migration multipliers diminishes the induced impacts associated with a change in direct employment.

The TSA and provincial employment multipliers used in the Arrow TSA analysis are as follows:

Table B-1. Employment multipliers, Arrow TSA

Forest sub-sector	Arrow TSA migration multiplier	Arrow TSA no-migration multiplier	Provincial (interior) migration multiplier	Provincial (interior) no-migration multiplier
Harvesting	1.48	1.29	2.14	1.80
Solid wood processing	1.54	1.32	2.29	1.93
Plywood	1.54	1.32	1.93	1.64
Pulp	1.93	1.65	3.02	2.48

Sources: Ministry of Finance and Corporate Relations. 1999. *The 1996 Forest District Tables*. Ministry of Finance and Corporate Relations. 1996. *A Provincial Impact Estimation Procedure for the British Columbia Forest Sector.*

Estimates of employment income

Employment income was calculated using average income estimates for workers in the forest industry. Based on Statistics Canada data, the weighted average annual pre-tax income (less benefits) in 1998 was:

$45,550 for workers in logging and forestry services;

$44,915 for workers in solid wood manufacturing; and,

$52,250 for workers in pulp and paper mills.

For those in indirect and induced occupations, the weighted average annual pre-tax income (less benefits) in 1998 was about $34,075. Income taxes were calculated based on marginal tax rates of 23-28% with one-third of the total income tax paid accruing to the province.

Employment estimates of alternative timber supply levels

To estimate employment generated by alternative timber supplies, the forecast harvest level is multiplied by the calculated employment coefficients. Note that employment coefficients are based on current industry productivity, harvest practices and forest management assumptions and will not likely reflect industry operating conditions in the future. Therefore, the employment estimates should be viewed as indicators of size of change rather than as precise estimates of changes in employment levels.

Provincial government revenues

Except for stumpage, royalty and rents, which are specific to the TSA, provincial government revenue impacts were estimated by using industry averages. Revenues per 1000 cubic metres of harvest, expressed as dollars per 1000 cubic metres, were calculated and applied to the harvest levels in the base case forecast in a manner similar to how employment impacts were estimated. Table B-2. summarizes the estimates of revenues that the provincial government receives from the forestry sector.

Table B-2. Estimates of provincial government revenues, Arrow TSA

Sources of revenue	Average annual revenue ($1998 millions)	Revenue ($ per '000s m³)
Stumpage and related payments[a]	9.76	17,750
Forest industry taxes[b]	4.77	8,664
Employee income tax[c]	4.83	8,788
Total	**19.36**	**35,202**

Note: Based on 1996–1998 average annual harvest of 550 105 cubic metres and related employment in the Arrow TSA. Due to rounding, figures for revenue per '000s m³ may not equal the quotient resulting from the division of average annual revenues by the 1996-1998 average harvest.

(a) Ministry of Forests, Revenue Branch.

(b) Based on estimates by Price Waterhouse Coopers (1999). Includes taxes for logging, corporate income, corporate capital, sales, property and electricity.

(c) Estimated from Revenue Canada income tax rates and includes only the provincial share of income taxes paid.